

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
6 January 2005 (06.01.2005)

PCT

(10) International Publication Number  
**WO 2005/000421 A2**

- (51) International Patent Classification<sup>7</sup>: **A63B**
- (21) International Application Number:  
PCT/US2004/020830
- (22) International Filing Date: 23 June 2004 (23.06.2004)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
60/480,668 23 June 2003 (23.06.2003) US  
60/555,434 22 March 2004 (22.03.2004) US  
10/875,049 22 June 2004 (22.06.2004) US
- (71) Applicant (for all designated States except US): NAU-  
TILUS, INC. [US/US]; 1400 NE 136th Avenue, Vancou-  
ver, WA 98684-0818 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): LULL, Andrew, P.  
[US/US]; 2639 Juniper Avenue, Boulder, CO 80304 (US).

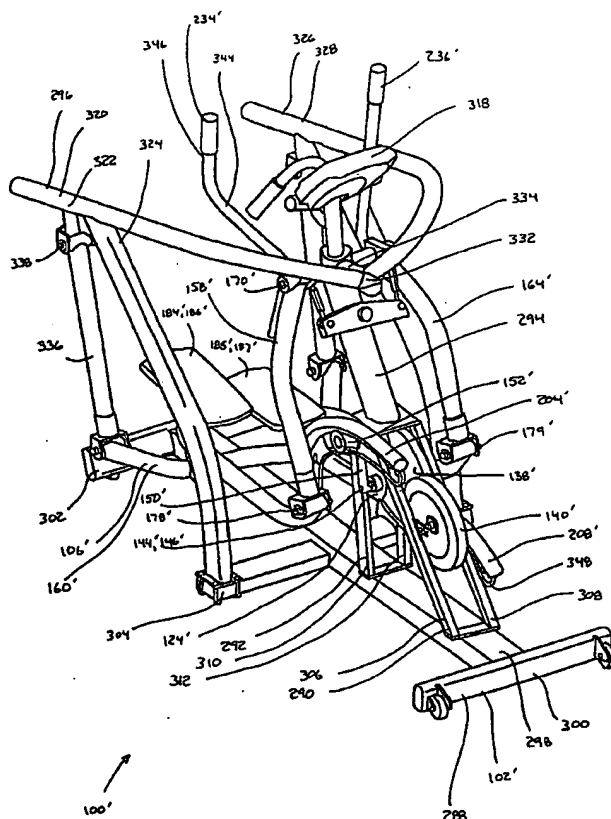
KRAPFL, Zachary, D. [US/US]; 414 Travis Gulch Road,  
Rollinsville, CO 80474 (US). KOWALEWSKI, Chester,  
F. [US/US]; 1601 Emerald Street, Broomfield, CO 80020  
(US). WATT, Jonathan, B. [US/US]; 4972 Greywolf  
Place, Broomfield, CO 80020 (US).

(74) Agents: MATSON, Charles et al.; Dorsey & Whitney  
LLP, 370 Seventeenth Street, Suite 4700, Denver, CO  
80202 (US).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,  
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,  
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,  
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,  
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,  
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,  
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,  
ZW.

[Continued on next page]

(54) Title: VARIABLE STRIDE EXERCISE DEVICE



(57) Abstract: The present invention provides for a  
variable stride exercise device having a variable size  
close curved striding path during use. The exercise  
device described and depicted herein utilizes various  
configurations of linkage assemblies, cam members,  
and other components, connected with a frame to  
allow a user to dynamically vary stride path during  
exercise. An exercise device conforming to aspects of  
the present invention provides a foot path that adapts  
to the change in stride length rather than forcing the  
user into a fixed size path. A user's exertion level may  
have several components impacting the stride length  
provided by the machine, such as leg power, torso  
power, and (in embodiments with arm supports or  
exercise components) arm power. Other embodiments  
of the exercise device include a lockout device that  
selectively eliminates the variable stride features of  
the exercise device and allows the user to exercise in  
a stepping motion.



(84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- as to the identity of the inventor (Rule 4.17(i)) for all designations
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ,

TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations

**Published:**

- without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

## **VARIABLE STRIDE EXERCISE DEVICE**

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims priority to U.S. Provisional Application No. 60/480,668, filed June 23, 2003; U.S. Provisional Application No. 60/555,434, filed March 22, 2004; and U.S. Non-Provisional Application titled, "Variable Stride Exercise Device," filed June 22, 2004 (Attorney Docket number 33270/US/2) with Express Mail Label No. EV423772193US, which are all hereby incorporated by reference in their entirety as though fully set forth herein.

U.S. Provisional Application titled, "Releasable Connection Mechanism for a Variable Stride Exercise Device," filed June 22, 2004 (attorney docket number 34477/US) with Express Mail Label No. EV 423 772 202 US; U.S. Provisional Application titled, "Variable Stride Exercise Device," filed June 22, 2004 (attorney docket number 34478/US) with Express Mail Label No. EV 423 772 216 US; U.S. Patent Application No. 10/789,182, filed on February 26, 2004; U.S. Patent Application No. 09/823,362, filed on March 30, 2001, now U.S. Patent No. 6,689,019; and U.S. Provisional Application No. 60/451,102, filed on February 28, 2003 are all hereby incorporated by reference in their entirety as though fully set forth herein.

### **BACKGROUND OF THE INVENTION**

#### **a. Field of the Invention**

This invention relates to exercise devices, and more particularly, to stationary striding exercise devices utilizing various linkage assembly configurations with components having various shapes and sizes to provide a footpath that can be dynamically varied by the user while exercising.

#### **b. Background Art**

A variety of exercise devices exist that allow a user to exercise by simulating a striding motion. Some of these exercise devices include a pair of foot-engaging links wherein first ends of each foot link are supported for rotational motion about a pivot point, and second ends of each foot link are guided in a reciprocal path of travel. The connection configuration of the two foot links may permit the user's foot to travel in a generally oval path of travel. However, the resulting foot travel path is a predetermined or fixed path that is defined by the structural configuration of the machine and can be varied only by manually changing physical parameters of the equipment. Thus, these exercise devices confine the range of motion of a user's foot by fixing the path traveled by the first and second ends of the foot links.

## BRIEF SUMMARY OF THE INVENTION

Aspects of the present invention involve an exercise device that provides a variable size foot path during use. More particularly, the exercise device includes a pair of foot platforms on which the user places his or her feet, and wherein each foot platform is operably connected with a corresponding linkage assembly. The foot platforms travel through a closed curved path of travel that varies as a function, at least in part, of the forces imparted by the user during exercise.

In one aspect of the present invention, an exercise device includes a frame, at least one swing link pivotally connected with the frame, and at least one crank arm pivotally connected with the frame and configured to rotate about a crank axis. The exercise device further includes at least one variable stride link supported by the at least one crank arm and the frame. The at least one variable stride link is coupled with the at least one crank arm to allow relative movement between the at least one variable stride link and the at least one crank arm along a first portion of the at least one variable stride link. At least one foot link is also pivotally connected with the at least one swing link and the at least one variable stride link.

In another form of the present invention, an exercise device includes a frame, a first member and a second member pivotally coupled with the frame, a first arm reciprocally coupled with the frame, a second arm reciprocally coupled with the frame, a third member movingly supported by the first arm and the frame, a fourth member movingly supported by the second arm and the frame, a fifth member pivotally coupled with the first member and the third member, and a sixth member pivotally coupled with the second member and the fourth member.

In yet another form of the present invention, an exercise device includes a frame, a first swing link and a second swing link pivotally connected with the frame, a first guide link and a second guide link pivotally connected with the frame, and a first crank arm and a second crank arm pivotally connected with the frame and configured to rotate about a crank axis. A first variable stride link is rollingly supported by the first crank arm and pivotally connected with the first guide link. A second variable stride link is rollingly supported by the second crank arm and pivotally connected with the second guide link. A first foot link is pivotally connected with the first swing link and the first variable stride link, and a second foot link is pivotally connected with the second swing link and the second variable stride link.

The features, utilities, and advantages of various embodiments of the invention will be apparent from the following more particular description of embodiments of the invention as illustrated in the accompanying drawings and defined in the appended claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a right side isometric view of a first embodiment of a variable stride exercise device.

Fig. 1B is a left side isometric view of the first embodiment of the variable stride exercise device.

Fig. 2 is a front view of the exercise device depicted in Fig. 1.

Fig. 3A is a right side schematic view of the exercise device depicted in Fig. 1 showing the right crank arm in about a 9 o'clock or rearward orientation and a right cam roller located at about the mid-point of the cam member.

Fig. 3B is a right side schematic view of the exercise device depicted in Fig. 1 showing a right crank arm in about a 12 o'clock or upper orientation and the right cam roller located at about the mid-point of a cam member.

Fig. 3C is a right side schematic view of the exercise device depicted in Fig. 1 showing the right crank arm in about a 3 o'clock or forward orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 3D is a right side schematic view of the exercise device depicted in Fig. 1 showing the right crank arm in about a 6 o'clock or lower orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 4A is a right side schematic view of the exercise device depicted in Fig. 1 showing a right crank arm in about a 9 o'clock or rearward orientation and the right cam roller located at a forward position on the right cam member.

Fig. 4B is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 12 o'clock or upper orientation and the right cam roller located at about the mid-point of a cam member.

Fig. 4C is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 3 o'clock or forward orientation and the right cam roller located at a rearward position on the right cam member.

Fig. 4D is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 6 o'clock or lower orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 5A is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 9 o'clock or rearward orientation and the right cam roller located at a forward position on the right cam member.

Fig. 5B is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 12 o'clock or upper orientation and the right cam roller located at about the mid-point of a cam member.

Fig. 5C is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 3 o'clock or forward orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 5D is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 6 o'clock or lower orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 6A is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 9 o'clock or rearward orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 6B is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 12 o'clock or upper orientation and the right cam roller located at about the mid-point of a cam member.

Fig. 6C is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 3 o'clock or forward orientation and the right cam roller located at a rearward position on the right cam member.

Fig. 6D is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 6 o'clock or lower orientation and the right cam roller located at about the mid-point of the cam member.

Fig. 7A is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 9 o'clock orientation with the right cam roller located at a rearward position on the right cam member and a left cam roller located at a forward position on a left cam member.

Fig. 7B is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 3 o'clock orientation with the right cam roller located at a forward position on the right cam member and the left cam roller located at a rearward position on the left cam member.

Fig. 7C is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 9 o'clock orientation with the right cam roller located at a forward position on the right cam member and the left cam roller located at a forward position on the left cam member.

Fig. 7D is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 4 o'clock orientation with the right cam roller located at a forward position on the right cam member and the left cam roller located at a forward position on the left cam member.

Fig. 7E is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 3 o'clock orientation with the right cam roller located at a forward position on the right cam member and the left cam roller located at a forward position on the left cam member.

Fig. 7F is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 7 o'clock orientation with the right cam roller located at a mid-position on the right cam member and the left cam roller located at a mid-position on the left cam member.

Fig. 7G is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 4 o'clock orientation with the right cam roller located at a forward position on the right cam member and the left cam roller located at a mid-rearward position on the left cam member.

Fig. 7H is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 4 o'clock orientation with the right cam roller located at a rearward position on the right cam member and the left cam roller located at a mid-rearward position on the left cam member.

Fig. 7I is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 2 o'clock orientation with the right cam roller located at a mid-position on the right cam member and the left cam roller located at a mid-position on the left cam member.

Fig. 7J is a right side schematic view of the exercise device depicted in Figs. 1A-1B showing the right crank arm in about a 10 o'clock orientation with the right cam roller located at a mid-rearward position on the right cam member and the left cam roller located at a rearward position on the left cam member.

Fig. 8 is an isometric view of the variable stride exercise device depicted in Figs. 1A-1B including a first alternative interconnection assembly.

Fig. 9 is an isometric view of the variable stride exercise device depicted in Figs. 1A-1B including a second alternative interconnection assembly.

Fig. 10 is an isometric view of a second embodiment of a variable stride exercise device.

Fig. 11 is a front view of the exercise device depicted in Fig. 11.

Figs. 12A and 12B are right side and left side views, respectively, of the exercise device depicted in Fig. 9 showing the right crank arm in the 9 o'clock or rearward position and the foot links in an expanded stride configuration.

Figs. 13A and 13B are right side and left side views, respectively, of the exercise device depicted in Fig. 9 showing the right crank arm transitioning to the 12 o'clock or upward position from the position shown in Figs. 12A and 12B.

Figs. 14A and 14B are right side and left side views, respectively, of the exercise device depicted in Fig. 9 showing the right crank arm in the 12 o'clock or upward position.

Fig. 15 is a detailed view of an interconnection assembly illustrated on the exercise device of Fig. 9.

Fig. 16 is an isometric view of an exercise device including a roller stop assembly.

Fig. 17 is an isometric view of the roller stop assembly of Fig. 16 showing the right cam link in contact with a roller.

Fig. 18 is an isometric view of an exercise device including a lockout device.

Fig. 19 is a right side view of the lockout device of Fig. 18.

## DETAILED DESCRIPTION OF THE INVENTION

Aspects of the present invention involve a variable stride exercise device providing a variable size close curved striding path during use. In some embodiments of the invention, the close curved striding path resembles an ellipse with a major and minor axis. The exercise



devices described and depicted herein utilize various configurations of linkage assemblies, cam members, and other components, connected with a frame to allow a user to dynamically vary his stride path during exercise. With reference to an embodiment providing an ellipse-like path, the major axis and/or the minor axis of the ellipse is modified, either lengthened or shortened, as a function of the user's stride. For example, if a user is exercising at a first exertion level and increases his exertion to a second level, his stride may lengthen due to the increase in exertion level. An exercise device conforming to aspects of the present invention provides a foot path that adapts to the change in stride length rather than forcing the user into a fixed size path as in some prior art devices. A user's exertion level may have several components impacting the stride length provided by the machine, such as leg power and frequency, torso power and frequency, and (in embodiments with arm supports or exercise components) arm power and frequency.

The embodiments are described herein with respect to the primary intended use of the embodiments. As such, the devices are described with the perspective of a user facing the front of the exercise machine. For example, components designated as "right" are on the right side of the device from the perspective of a user operating the device. Additionally, the primary intended use is for a forward pedaling stride, such as when a person, walks, climbs, jogs, or runs forwardly. It is possible, however, that users will operate the machines standing backward, will pedal backward, or will stand and pedal backward. Aspects of the invention are not necessarily limited to the orientation of a user or any particular user's stride.

A first embodiment of an exercise device 100 conforming to aspects of the present invention is shown in Figs. 1A-2. The exercise device 100 includes a frame 102 having a left linkage assembly 104 and a right linkage assembly 106 connected therewith. The left linkage assembly 104 is substantially a mirror image of the right linkage assembly. The frame includes a base portion 108, a fork assembly 110, a front post 112, and a rear post 114. The combination of the fork assembly, the front post, and the rear post pivotally supports the linkage assemblies as well as supports the components that variably support the linkage assemblies.

The fork assembly 110, the front post 112, and the rear post 114 define an A-frame like support structure 116. More particularly, the fork assembly 110 and the rear post 114 are connected with the base portion 108. At the front of the device, the fork assembly 110 extends upwardly and rearwardly from the base portion 108. The front post 112 extends upwardly from the fork assembly 110 in the same direction as the fork assembly relative to

the base portion. Rearward of the fork assembly 110, the rear post 114 extends upwardly and forwardly from the base portion 108 and intersects with the top area of the front post 112. It is to be appreciated that various frame configurations and orientations can be utilized with the present invention other than what is depicted and described herein.

The A-frame support assembly 116 is secured to a right base member 118 and a left base member 120. The fork assembly 110 includes a right fork member 122 supporting a right crank suspension bracket 124, and a left fork member 126 supporting a left crank suspension bracket 128. The right fork member 122 and the left fork member 126 extend upwardly and rearwardly from the right base member 118 and the left base member 120, respectively. The right crank suspension bracket 124 is L-shaped and has a horizontal portion 130 extending rearwardly from the right fork member and a vertical portion 132 extending downwardly from the right fork member to intersect the horizontal portion at substantially a right angle. The left crank suspension bracket 128 is connected with the left fork member 126 and is substantially a mirror image of the right crank suspension member 124. The front post 112 is attached to the fork assembly 110 at the connection of the vertical portion 132 of the right crank suspension bracket 124 with the right fork member 122 and the connection of the vertical portion 132 of the left crank suspension bracket 128 with the left fork member 126. A right brace member 134 and a left brace member 136 extend upward from the right base member 118 and the left base member 120, respectively, to connect with right and left crank suspension brackets, respectively.

Still referring to Figs. 1A-2, the A-frame 116 rotatably supports a pulley 138 and a flywheel 140. More particularly, the pulley 138 is rotatably supported between bearing brackets 142 extending rearwardly from the right and left crank suspension brackets 124 and 128, respectively. The pulley includes a crank axle 144, which defines a crank axis 146. Left and right crank arms 148 and 150 are connected with the crank axle 144 to rotate about the crank axis 146 along repeating circular paths. In addition, the right and left crank arms are configured to travel 180 degrees out of phase with each other. Distal the crank axle, a right cam roller 152 and a left cam roller 154 are rotatably connected with the right crank arm 150 and the left crank arm 148, respectively. As discussed in more detail below, the right and left cam rollers variably support the front portion of the linkage assemblies.

The flywheel 140 is rotatably supported between the left and right fork members 126 and 122. A belt 156 couples the pulley 138 with the flywheel 140. As such, via the pulley, the flywheel is indirectly coupled to the right and left crank arms 150 and 148 so that rotation

of the crank arms is coupled with the flywheel. The flywheel provides a large angular momentum to give the overall movement of the linkages and crank arms a smooth feel during use. For example, the flywheel configured with a sufficiently heavy perimeter weight helps turn the crank arms smoothly even when the user is not supplying a turning force and promotes a smooth movement of the of linkage assemblies as the crank arms move through the 6 o'clock and 12 o'clock positions where the user imparts little force on the cranks.

As shown in Figs. 1A-2, the right linkage assembly 106 includes a right swing link 158, a right cam link 160, and a right foot link 162 operably connected with the right crank arm 150 and the frame 102 to provide a variable stride path. Although the following description refers mainly to the components of the right linkage assembly, it is to be appreciated that the left linkage assembly is substantially a mirror image of the right linkage assembly, and as such, includes the same components as the right linkage assembly, which operate in relation with each other and with the frame as the right linkage assembly. For example, the left linkage assembly includes a left swing link 164, a left cam link 166, and a left foot link 168 operably connected with the left crank arm 148 and the frame 102 to provide a variable stride path. The right swing link 158 is pivotally supported near the apex of the A-frame support 116. More particularly, the top portion of the front post 112 defines an upper pivot 170 above the intersection of the front post 112 and the rear post 114. The right 158 (and left 164) swing link is pivotally supported at the upper pivot 170. In one particular implementation, the swing link defines an arm exercise portion 172 extending upwardly from the upper pivotal connection 170. Without an arm exercise, the swing arm is shorter and pivotally supported near its top portion.

A lower portion 174 of the right swing link 158 is pivotally connected with a forward portion 176 of the right foot link 162 at a right lower pivot 178. The swing link 158 of Fig. 1A defines a forwardly extending bottom portion 180 angularly oriented with respect to a top portion 182. Although the right and left swing links depicted in Figs. 1A and 1B are shown as bent (so as to define an angle between straight end portions), it is to be appreciated other embodiments of the present invention can utilize swing links defining other shapes, such as straight or arcuate.

Although various embodiments of the invention described herein include pivotally connected or supported links, it is to be appreciated that the pivotal connections may be provided with various possible configurations of ring bearings, collars, posts, pivots, and other pivotal or rotatable arrangements. Moreover, the pivotal connections may be direct,

such as in a pivotal connection between a first link and a second link where one link has a pin or rod pivotally supported by one or more ring bearings housed in a circular aperture of the second link, or may be indirect, such as when a third link is interposed between the first and second link.

As introduced above, the forward portion 176 of the right foot link 162 is pivotally coupled with the lower portion 174 of the right swing link 158. The right foot link 162 is also pivotally coupled with the right cam link 160 rearward of the right swing link. The rearward portion of the right foot link supports a right foot engaging portion 184. The foot engaging portion 184, in one example, includes a rectangular foot pad 186 meant to support a user's foot. The foot engaging portions may be directly connected with the top of the foot links or may be pivotally supported so that they articulate during use or their angular relations with the foot links vary.

The right foot link 162, between the forward and rearward ends thereof, is pivotally connected with the right cam link 160, between the forward and rearward ends thereof, at a right cam link pivot 188. Similarly, in a mirror image of the right linkage assembly, the left foot link 164, between the forward and rearward ends thereof, is pivotally connected with the left cam link 166, between the forward and rearward ends thereof, at a left cam link pivot 190. It is to be appreciated that the locations of the pivotal connections between the foot links and the cam links are not limited to the locations shown in the figures, but may be otherwise located between the ends of the links. As discussed in more detail below, when using the exercise device, the user mounts the exercise device by placing his feet on the right and left foot engaging portions 184, 185 provided toward the rear portions of the right and left foot links. Movement imparted to the right and left foot links 162 and 168 by the user causes the right and left swing links 158 and 164 to swing back and forth about the upper pivot. The travel paths in which the foot engaging sections move is dictated in part by the movement of the right and left cam links and the stride length of the user.

Still referring to Figs. 1A-2, a right guide roller 192 is rotatably connected with a rear portion 194 of the right cam link 160, and a left guide roller 196 is rotatably connected with a rear portion 198 of the left cam link 166. The frame includes a left 200 and a right rail 202. The right and left guide rollers 196 and 198 are adapted to roll back and forth along the right rail and the left rail, respectively. The guide rollers may also be adapted to roll along other surfaces, such as the floor. Although the right and left rails are flat (i.e., level) the rails may also be inclined or declined, and may be arcuately-shaped with a fixed or varying radius.

As shown in Figs. 1A-2, a right cam member 204 is connected with a forward portion 206 of the right cam link 160, and a left cam member 208 is connected with a forward portion 210 of the left cam link 166. Each cam member includes a downwardly concave section 212 defining a generally arcuate surface 214. The arcuate surface 214 is adapted to rest on the cam roller (152, 154) on the end of the crank arm (150, 148). As such, the forward portion 206 of the right cam link 160 is supported by the right cam roller 152 and the forward portion 210 of the left cam link 166 is supported by the left cam roller 154. The crank arm is thus not coupled with the cam link in a fixed relation. Rather, via the roller/cam interface, the cam link may move relative to the crank arm. As such, as discussed in more detail below, the cam links (160, 166) act as variable stride links that allow a user to move the foot links (162, 168) by varying his stride length. During use, the crank arms (148, 150) rotate about the crank axis 146. The cam rollers (152, 154) also rotate about the crank axis 146, moving through an arcuate path having vertical and horizontal components. During use, the cam members ride on the rollers as the crank arms rotate about the crank axis. Depending on the horizontal forces applied to the cam links, the cam rollers are adapted to roll back and forth along the arcuate cam surfaces of the right and left cam members in relation to forward and rearward movement of the right and left cam links when the exercise device is in use.

The arcuate surfaces 214 of the cam members (204, 200) shown in Figs. 1A-1B and others define a variable radius, with the radius being longer in the middle and shorter toward the ends. As the radius decreases, the force required to move the roller along the cam surface increases, thus, as a user's stride increases, it takes a greater force to move the cams (204, 208) relative to the crank arms (150, 148). The arcuate surfaces 214 may also define a fixed radius. At either end of the cam surfaces, the generally concave sections define downwardly extending nearly vertical, portions. The downwardly extending portions of the arcuate cam surfaces of the right and left cam members act to keep the cam members and the cam links from disengaging from the crank arms. It is also possible to utilize hard stops or some other mechanism that prohibits the roller from disengaging the crank.

To operate the exercise machine 100 shown in Figs. 1A-2, a user first places his feet in operative contact with the right and left foot engagement portions 184. To begin operation of the machine in a forward stride exercise, the user places his weight predominantly on the foot pad 186 located upwardly and/or forwardly relative to the other foot pad along with some forward force imparted by the user's foot. As a result, the crank arms (148, 150) will begin rotation in a clockwise direction (as viewed from the right side of the exercise device). The user then proceeds to exercise by continuing to stride forwardly toward the front post.

Forces imparted to the foot engaging portions 184 by the user cause the foot links (162, 168) to move back and forth, which in turn cause the swing links (158, 164) to pivot back and forth around the upper pivot 170. At the same time, the crank arms (148, 150) rotate around the crank axis 146. Because the foot links (162, 168) and the cam links (160, 166) are rollingly supported by the rails (202, 200) and the crank arms (150, 148) through rollers (152, 154, 192, 196), the paths in which the cam links and foot links move are variable and can be affected by the stride length of the user. As such, the foot paths are not solely dictated by the geometric constraints of the intercoupling of the foot links, cam links, swing links, crank arms, and the frame. Therefore, the user can dynamically adjust the travel path of the of the foot engaging sections while using the exercise device based on the user's natural stride length, stride power, and stride rate.

A comparison of Figs. 3A-3D illustrates the relative movement of the various components of the linkage assemblies as the right crank arm 150 moves through one full rotation from a the rearward orientation (Fig. 3A), to an upward orientation (Fig. 3B), to a forward orientation (Fig. 3C), and to a downward orientation (Fig. 3D), and back to the rearward orientation for a given user stride length. In Figs. 3A-3D, the cam members (204, 208) are shown in fixed relation to the cam rollers (152, 154) at a midpoint or apex 232 of the cam surfaces. The cam rollers will stay near the midpoint of the cam surfaces when little or no forward or rearward force component is placed on the foot engaging portions 184 by a user. As discussed in more detail below, the right and left linkage assemblies 106 and 104 can be interconnected so that forward movement of one causes rearward movement of the other, and vice versa. Therefore, it is to be appreciated that the components of the left linkage assembly may move relative to each other in the same way as the right linkage assembly components, but in an opposite direction relative to the right linkage assembly components when an interconnection assembly is utilized.

Referring first to Fig. 3A, the right and left foot pads 186 and 187 are oriented such that the user's right foot is placed rearwardly of his left foot. In addition, the user's right foot is positioned such that the user's right heel is slightly raised relative to the user's right toes, and the user's left foot is positioned such that the user's left heel is slightly higher relative to the user's left toes. As the user strides forward with his right leg toward the front post 112, the right crank arm 150 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the rearward orientation (Fig. 3A) to the upward orientation (Fig. 3B), which causes the lower portion 174 of the right swing link 158 to pivot counterclockwise from a rearward position shown in Fig. 3A around the upper pivot

170 to the position shown in Fig. 3B. At the same time, the right guide roller 192 rolls forwardly along the right rail 202. The rearward portion 194 of the right cam link 160 moves forwardly in conjunction with the movement of the right guide roller 192, and the forward portion 206 of the right cam link 160 moves upwardly and forwardly in conjunction with the movement of the right cam roller 152 connected with the right crank arm 150. In the particular stride path shown in Figs. 3A and 3B, the right cam roller does not move along the length of the right cam surface.

A right forward step is accompanied by rearward movement of the left leg. The left crank 148 rotates in coordination with the right crank 150. Thus, the left crank arm 148 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the forward orientation to the downward orientation, which causes a lower portion 175 of the left swing link 164 to pivot clockwise from a forward position shown in Fig. 3A around the upper pivot 170 to the position shown in Fig. 3B. At the same time, the left guide roller 196 rolls rearwardly along left rail 200. The rearward portion 198 of the left cam link 166 moves rearwardly in conjunction with the movement of the left guide roller 196, and the forward portion 210 of the left cam link 166 moves downwardly and rearwardly in conjunction with the movement of the left cam roller 154 connected with the left crank arm 148. In the particular stride path shown in Figs. 3A and 3B, the left cam roller 154 does not move along the length of the left cam surface. The beginning movement of the left linkage assembly 104 is similar to the movement of the right linkage 106 assembly shown and discussed below with reference to Figs. 3C and 3D.

As shown in Fig. 3B, the right foot pad 186 has moved upward and forward from the position shown in Fig. 3A, and the left foot pad 187 has moved downward and rearward from the position shown in Fig. 3A. As such, in Fig. 3B, the right and left pads are oriented such that the user's right foot is placed upward relative to his left foot. In addition, the user's right foot is positioned such that the user's right heel is raised relative to the user's right toes, and the user's left foot is positioned such that the user's left heel is almost level with the user's left toes.

As the user continues to stride forward toward the front post 112, the right crank arm 150 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the upward orientation (Fig. 3B) to the forward orientation (Fig. 3C). At the same time, the lower portion 174 of the right swing link 158 pivots counterclockwise from the position shown in Fig. 3B around the upper pivot 170 to a forward

position shown in Fig. 3C. In coordination, the right guide roller 192 continues to roll forwardly along the right rail 202. The rearward portion 194 of the right cam link 160 moves forwardly in conjunction with the movement of the right guide roller 202, and the forward portion 206 of the right cam link 160 moves downwardly and forwardly in conjunction with the movement of the right cam roller 152 connected with the right crank arm 150. In the particular stride path shown in Figs. 3B and 3C, the right cam roller 152 does not move along the length of the right cam surface.

With reference to the left linkage assembly 104, the left crank arm 148 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis from the downward orientation (Fig. 3B) to a rearward orientation (Fig. 3C), which causes the lower portion 175 of the left swing link 164 to pivot clockwise from the position shown in Fig. 3B around the upper pivot 170 to a rearward position shown in Fig. 3C. At the same time, the left guide roller 196 continues to roll rearwardly along the left rail 200. The rearward portion 198 of the left cam link 166 moves rearwardly in conjunction with the movement of the left guide roller 196, and the forward portion 210 of the left cam link 166 moves upwardly and rearwardly in conjunction with the movement of the left cam roller 154 connected with the left crank arm 148. In the particular stride path shown in Figs. 3B and 3C, the left cam roller does not move along the length of the left cam surface.

As shown in Fig. 3C, the right foot pad 186 has moved downward and forward from the position shown in Fig. 3B, and the left foot pad 187 has moved upward and rearward from the position shown in Fig. 3B. As such, in Fig. 3C, the right and left pads are oriented such that the user's right foot is placed forward relative to his left foot. In addition, the user's right foot is positioned such that the user's right heel is slightly raised relative to the user's right toes, and the user's left foot is positioned such that the user's left heel is slightly raised relative to the user's left toes.

From the linkage orientation of Fig. 3C to Fig. 3D, the user's right leg transitions from a forward movement to a rearward movement. As such, the user begins the rearward portion or second half of a full stride. As the user begins, the right crank arm 150 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the forward orientation rearwardly to the downward orientation (Fig. 3D). At the same time, the lower portion 174 of the right swing link 158 pivots clockwise from the forward position shown in Fig. 3C around the upper pivot 170 back to the position shown in Fig. 3D. In coordination, the right guide roller 192 begins rolling rearwardly along the right



rail 202. The rearward portion 194 of the right cam link 160 moves rearwardly in conjunction with the movement of the right guide roller 192, and the forward portion 206 of the right cam link 160 moves downwardly and rearwardly in conjunction with the movement of the right cam roller 152 connected with the right crank arm 150. In the particular stride path shown in Figs. 3C and 3D, the right cam roller does not move along the length of the right cam surface.

At the same time, the left linkage 104 transitions from rearward movement to forward movement. The left crank arm 148 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the rearward orientation (Fig. 3C) to the upward orientation (Fig. 3D). At the same time, the lower portion 175 of the left swing link 164 pivots counterclockwise from the rearward position shown in Fig. 3C around the upper pivot 170 back to the position shown in Fig. 3D. In coordination, the left guide roller 196 begins to roll forwardly along left rail 200. The rearward portion 198 of the left cam link 166 moves forwardly in conjunction with the movement of the left guide roller 196, and the forward portion 210 of the left cam link 166 moves upwardly and forwardly in conjunction with the movement of the left cam roller 154 connected with the left crank arm 148. In the particular stride path shown in Figs. 3C and 3D, the left cam roller does not move along the length of the left cam surface.

As shown in Fig. 3D, the right foot pad 186 has moved rearward and downward from the position shown in Fig. 3C, and the left foot pad 187 has moved upward and forward from the position shown in Fig. 3C. As such, in Fig. 3D, the right and left pads are oriented such that the user's right foot is placed downward relative to his left foot. In addition, the user's right foot is positioned such that the user's right heel is almost level with the user's right toes, and the user's left foot is positioned such that the user's left heel is raised relative to the user's left toes.

As the user continues the rearward portion of the stride away from the front post 112, the right crank arm 150 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the downward orientation (see Fig. 3D) back to the rearward orientation (see Fig. 3A) to complete one full stride. At the same time, the lower portion 174 of the right swing link 150 pivots clockwise from the position shown in Fig. 3D around the upper pivot 170 back to the rearward position shown in Fig. 3A. In coordination, the right guide roller 192 continues to roll rearwardly along right rail 202. The rearward portion 194 of the right cam link 160 moves rearwardly in conjunction with the

movement of the right guide roller 192, and the forward portion 206 of the right cam link 160 moves upwardly and rearwardly in conjunction with the movement of the right cam roller connected with the right crank arm. In the particular stride path shown in Figs. 3D and 3A, the right cam roller does not move along the length of the right cam surface. Referring to the left linkage assembly 104, the left crank arm 148 rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146 from the upward orientation (see Fig. 3D) to the forward orientation (see Fig. 3A). At the same time, the lower portion 175 of the left swing link 164 pivots counterclockwise from the position shown in Fig. 3D around the upper pivot 170 back to forward position shown in Fig. 3A. In conclusion, the left guide roller 196 continues to roll forwardly along the left rail 200. The rearward portion 198 of the left cam link 166 moves forwardly in conjunction with the movement of the left guide roller, and the forward portion 210 of the left cam link 166 moves downwardly and forwardly in conjunction with the movement of the left cam roller connected with the left crank arm. In the particular stride path shown in Figs. 3D and 3A, the left cam roller does not move along the length of the left cam surface.

As previously mentioned, a user can vary his stride length while using the exercise device. More particularly, a user of the exercise device during more rigorous exercise can lengthen his stride by applying additional force to the foot pads, because the cam links are connected with the crank arms through cam rollers in rolling engagement with cam surfaces of the cam links, i.e., the cam links are not pivotally connected in fixed relation to the crank arms. Forces applied to the foot pads are translated from the foot links to the cam links through the cam link pivots, which can cause the cam links to move relative to the crank arms by causing the cam rollers to roll along the length of the cam surface.

In one example, a comparison of Figs. 3A-3D with Figs. 4A-4D illustrates orientations of the linkages associated with a user dynamically changing the movement of linkage assemblies to accommodate a lengthened stride, such as during more vigorous exercise. As described above, Figs. 3A-3D illustrate the relative movements of the linkage components for the exercise device as the crank arms (150, 148) complete one full rotation while cam rollers (152, 154) stay near the midpoint of the cam surfaces. An ellipse 216 shown in dash in Figs. 3A-3D represents the foot path of the right foot pad 186 as the crank arms complete one full rotation. Figs. 4A-4D illustrate the relative movements of the linkage components for the exercise device as the crank arms complete one full rotation while the user extends his stride length when the crank arms are in the forward and rearward orientations. An ellipse 218 shown in dash in Figs. 4A-4D represents the foot path of the

right foot pad 186 as the crank arms complete one full rotation. A longer user stride in Figs. 4A-4D is illustrated by comparing the foot path 218 shown in Figs. 4A-4D with the foot path 216 shown in Figs. 3A-3D. The oblong shape of the foot path 218 is accentuated in Figs. 4A-4D as it stretches further in both forward and rearward horizontal directions than the foot path 216 shown in Figs. 3A-3D.

As shown in Figs. 3A and 4A, the right crank arm 150 is in a rearward orientation. As discussed above, in Fig. 3A, the right and left cam rollers (152, 154) are located near or at the midpoint or apex 232 of cam surfaces of the right and left cam members (204, 208), respectively, such as when a user is exercising at a low exertion level. In contrast, in Fig. 4A, the right cam roller 152 is engaged with the downwardly extending portion of the cam surface located near a forward end 220 of the right cam member 204, such as during vigorous exercise. As such, the right cam link 160, the right cam link pivot 188, and the right foot link 162 in Fig. 4A are located in positions rearward of that which is illustrated in Fig. 3A. In Fig. 4A, the left cam roller 154 is engaged with the downwardly extending portion of the cam surface located near a rearward end 222 of the left cam member 208. As such, the left cam link 166, the left cam link pivot 190, and the left foot link 168 in Fig. 4A are located in positions forward of that which is illustrated in Fig. 3A. Therefore, the foot pads (186, 187) illustrated in Fig. 4A are separated by a greater distance than the foot pads illustrated in Fig. 3A, which equates to a longer user stride length in illustrated in Fig. 4A than in Fig. 3A for the same crank arm orientation.

Similarly, as shown in Figs. 3C and 4C, the right crank arm 150 is in a forward orientation. In Fig. 3C, the right and left cam rollers (152, 154) are located near or at the midpoint or apex 232 of cam surfaces of the right and left cam members (204, 208), respectively, such as when a user is exercising at a low exertion level. In contrast, in Fig. 4C, the right cam roller 152 is engaged with the downwardly extending portion of the cam surface located near a rearward end 224 of the right cam member 204, such as during vigorous exercise. As such, the right cam link 160, the right cam link pivot 188, and the right foot link 162 in Fig. 4C are located in positions forward of that which is illustrated in Fig. 3C. In Fig. 4C, the left cam roller 154 is engaged with the downwardly extending portion of the cam surface located near a forward end 226 of the left cam member 208. As such, the left cam link 166, the left cam link pivot 190, and the left foot link 168 in Fig. 4C are located in positions rearward of that which is illustrated in Fig. 3C. Therefore, the foot pads (186, 187) illustrated in Fig. 4C are separated by a greater distance than the foot pads illustrated in Fig.

3C, which equates to a longer user stride length in Fig. 4C than in Fig. 3C for the same crank arm orientation.

It is to be appreciated that the user may vary his stride length by varying amounts at any crank arm orientation. For example, a comparison of Figs. 3A-3D with Figs. 5A-5D illustrates orientations of the linkages associated with a user dynamically lengthening his stride in a rearward direction. A longer user stride in the rearward direction shown in Figs. 5A-5D is illustrated by comparison to a foot path 228 shown in dash in Figs. 5A-5D with the foot path 216 shown in Figs. 3A-3D. The oblong shape of the foot path 228 is accentuated in Figs. 5A-5D as it stretches further in the rearward horizontal direction than the foot path 216 shown in Figs. 3A-3D.

As shown in Figs. 3A and 5A, the right crank arm 150 is in a rearward orientation. As discussed above, in Fig. 3A, the right and left cam rollers (152, 154) are located near or at the midpoint or apex of cam surfaces of the right and left cam members (204, 208), respectively. In contrast, in Fig. 5A, the right cam roller 152 is engaged with the downwardly extending portion of the cam surface located near the forward end 220 of the right cam member 204. As such, the right cam link 160, the right cam link pivot 188, and the right foot link 162 in Fig. 5A are located in positions rearward of that which is illustrated in Fig. 3A. As shown in Fig. 5A, the left cam roller 154 is similarly engaged the cam surface of the left cam member 208 as depicted in Fig. 3A. Therefore, the foot pads (186, 187) illustrated in Fig. 5A are separated by a greater distance than the foot pads illustrated in Fig. 3A, due to the rearward positioning of the right foot pad 187 in Fig. 5A.

Similarly, as shown in Figs. 3C and 5C, the right crank arm 150 is in a forward orientation. In Fig. 3C, the right and left cam rollers (152, 154) are located near or at the midpoint or apex 232 of cam surfaces of the right and left cam members (204, 208), respectively. In contrast, in Fig. 5C, the left cam roller 154 is engaged with the downwardly extending portion of the cam surface located near the forward end 226 of the left cam member 208. As such, the left cam link 166, the left cam link pivot 190, and the left foot link 168 in Fig. 5C are located in positions rearward of that which is illustrated in Fig. 3C. As shown in Fig. 5C, the right cam roller 152 is similarly engaged with the cam surface of the right cam member 204 as depicted in Fig. 3C. Therefore, the foot pads (186, 187) illustrated in Fig. 5C are separated by a greater distance than the foot pads illustrated in Fig. 3C, due to the rearward positioning of the left foot pad 187 in Fig. 5C.

In yet another example, a comparison of Figs. 3A-3D with Figs. 6A-6D illustrates orientations of the linkages associated with a user dynamically lengthening his stride in a forward direction. A longer user stride in the rearward direction shown in Figs. 6A-6D is illustrated by comparison to a foot path 230 shown in dash in Figs. 6A-6D with the foot path shown in Figs. 3A-3D. The oblong shape of the foot path 230 is accentuated in Figs. 6A-6D as it stretches further in the forward horizontal direction than the foot path 216 shown in Figs. 3A-3D.

As shown in Figs. 3A and 6A, the right crank arm 150 is in a rearward orientation. As discussed above, in Fig. 3A, the right and left cam rollers (152, 154) are located near or at the midpoint or apex 232 of cam surfaces of the right and left cam members (204, 208), respectively. In contrast, in Fig. 6A, the left cam roller 154 is engaged with the downwardly extending portion of the cam surface located near the rearward end 222 of the left cam member 208. As such, the left cam link 166, the left cam link pivot 190, and the left foot link 168 in Fig. 6A are located in positions forward of that which is illustrated in Fig. 3A. As shown in Fig. 6A, the right cam roller 152 is similarly engaged with the cam surface of the right cam member 204 as depicted in Fig. 3A. Therefore, the foot pads (186, 187) illustrated in Fig. 6A are separated by a greater distance than the foot pads illustrated in Fig. 3A, due to the forward positioning of the left foot pad 187 in Fig. 6A.

Similarly, as shown in Figs. 3C and 6C, the right crank arm 150 is in a forward orientation. In Fig. 3C, the right and left cam rollers (152, 154) are located near or at the midpoint or apex 232 of cam surfaces 152 of the right and left cam members (204, 208), respectively. In contrast, in Fig. 6C, the right cam roller 152 is engaged with the downwardly extending portion of the cam surface located near the rearward end 224 of the right cam member 204. As such, the right cam link 160, the right cam link pivot 188, and the right foot link 162 in Fig. 6C are located in positions forward of that which is illustrated in Fig. 3C. As shown in Fig. 6C, the left cam roller is similarly engaged the cam surface of the left cam member as depicted in Fig. 3C. Therefore, the foot pads illustrated in Fig. 6C are separated by a greater distance than the foot pads illustrated in Fig. 3C, due to the forward positioning of the right foot pad in Fig. 6C.

Figs. 7A-7J further illustrate various examples of linkage component orientations that may occur during use of the exercise device 100. These various component orientations may result in differently shaped foot paths for a particular user. As such, it is to be appreciated that use of the exercise device is not limited to various foot paths illustrated in the

accompanied figures. As previously mentioned, the user can dynamically adjust the travel path of the of the foot engaging sections while using the exercise device based on the user's natural stride length, stride power, and stride rate, which can result in numerous and varying types of foot paths for a particular user.

People naturally vary their stride during exercise. An exercise device conforming to the present invention accommodates these natural stride variations without forcing a user into a fixed stride length and shape. As discussed above, when a user varies his stride length while using the exercise device, the distance in which the cam members (204, 206) move along the cam rollers (152, 154) also varies along with the distance the guide rollers (192, 196) move along the rails (202, 200). For example, as the user increases his stride length, the distance that the cam members pass over the cam rollers increases. Moreover, the distance that the guide rollers move along the rails also increases. As such, it is to be appreciated that varying the contours and orientations of the rails and cam surfaces affect how the foot engaging portions move for varying stride lengths. Therefore, other embodiments of the exercise device can utilize various lengths, shapes, and orientations of the rails and cam surfaces so as to alter how the user's foot will move throughout a given stride length.

The contour shapes, lengths, and orientations of the cam surfaces 214 and rails (202, 200) can affect the forces required to provide a variable stride as well as the forces required to move the cam links (160, 166) with respect to the cam rollers (152, 154). For example, if the radii defining the cam surfaces 214 are increased, it will require less force to move the cam link relative to the crank arm, and thus, less force to vary user stride. In contrast, if the radii defining the cam surfaces are decreased, it will require greater force to move the cam links relative to the crank arms, and thus, greater force to vary user stride. If the radii defining the cam surfaces are decreased at the forward and rearward ends of the cam surfaces with a greater radii between the ends, for example, then the amount of force required to move the cam link at the ends of the cam surface will be greater than moving it along the greater radii areas. In addition, longer cam surfaces will allow a user to dynamically increase his stride length over greater distances.

As shown in Figs. 1A-2, the exercise device 100 may also include lever arms (234, 236) connected with or integral to the swing links (158, 164). The lever arms provide an extra gripping surface for the user as well as allowing the user to complement his use of the exercise device with an upper body workout. The lever arms (234, 236) extend from the respective swing links (158, 164) at the location of the upper pivot 170 to provide hand grips

for a user of the exercise device. The lever arms form rigid mechanical extensions of the swing links, and rotate about the upper pivot. In operation, the user of the exercise machine grips one of lever arms in each of his left and right hands, and pulls or pushes on the lever arms in coordination with the rearwardly and forwardly movement of the foot links (162, 168). Thus, forward movement of the lever arms above the upper pivot is accompanied by rearward movement of the swing arm below the upper pivot. Moreover, as the lever arms impact a force on the foot links, the forces from the lever arms may also act to cause a variation in the stride path.

As previously mentioned, an exercise device conforming to the present invention may include an interconnection assembly that causes the components of the right and left linkage assemblies to move in opposite directions relative to each other. Such an interconnection assembly is not necessary. The interconnection assemblies disclosed herein and variations thereof can be used with any embodiments of the exercise device disclosed herein. It is to be appreciated that these interconnection assemblies may be configured differently, and should not be limited to the configurations discussed and depicted herein.

Referring back to Figs. 1A-1B, an interconnection assembly 238 involving a cable and pulleys is shown. The interconnection assembly 238 includes a right rear pulley 240 and a left rear pulley 242 pivotally supported on a cross member 244 connected with the right rail 202 and left rail 200, and a right front pulley 246 and a left front pulley 248 pivotally supported on the right base member 118 and the left base member 120, respectively. The pulleys are generally located rearward of the rearward most position of the guide rollers (192, 196) and forward of the forward most position of the guide rollers.

A cable 250 (which may be connected sections of cable) is routed around each of the pulleys. The cable is also connected with each cam link (160, 166) near the guide rollers (192, 196). As such, forward motion of the right cam link 160 (and corresponding right linkage assembly 106) imparts a forward motion to the section of cable 250 between the right rear pulley 240 and the right front pulley 246. This in turn translates to a rearward motion to the section of cable 250 between the left rear pulley 242 and the left front pulley 248, which imparts a rearward force on the left cam link 166 (and corresponding left linkage assembly 104). Conversely, rearward motion of the right cam link 160 (and corresponding right linkage assembly) imparts a rearward motion to the section of cable between the right rear pulley 240 and the right front pulley 246. This in turn translates to a forward motion to the

section of cable between the left rear pulley 242 and the left front pulley 248, which imparts a forward force on the left cam link 166 (and corresponding left linkage assembly).

An alternative interconnection assembly 252 is shown in Fig. 8, which includes a forward extending U-bracket 254 pivotally connected with the front post 112. A teeter member 256 is pivotally supported in the U-bracket 254 such that it extends outwardly in left and right directions from each side of the U-bracket. A right interconnecting link 256 is pivotally connected with a right side 260 of the teeter member 256 and extends from the teeter member to pivotally connect with the right swing link 158. A left interconnecting link 262 is pivotally connected with a left side 264 of the teeter member 256 and extends from the teeter member to pivotally connect with the left swing link 164. It is to be appreciated that the various pivots may be straight pin type pivots, universal joints, ball joints, and the like. Moreover, the pivots may be adapted to move laterally with respect to whatever member with which they are connected. In addition, some of the pivotal connections may be eliminated depending on the particular joint configuration used. With the interconnection assembly 252 shown in Fig. 8, forward motion of the right swing link 158 (and corresponding right linkage assembly 106) imparts a forward motion to the right interconnection link 258, which causes the teeter member 256 to pivot about the U-bracket 254. This in turn imparts a rearward motion on the left interconnection link 262, which imparts a rearward force on the left swing link 164 (and corresponding left linkage assembly 104). Conversely, rearward motion of the right swing link 158 (and corresponding right linkage assembly) imparts a rearward motion to the right interconnection link 258, which causes the teeter member 256 to pivot about the U-bracket 254. This in turn imparts a forward motion on the left interconnection link 262, which imparts a forward force on the left swing link 164 (and corresponding left linkage assembly).

A second alternative embodiment 266 of an interconnection assembly is illustrated in Fig. 9 and includes a teeter member 268, a right interconnection link 270, a left interconnection link 272, a right U-bracket 274, and a left U-bracket 276. A teeter axle 278 extends forwardly from the front post 112 and is adapted to pivotally support the teeter member 268. The left interconnection link 272 is pivotally connected with a left portion 280 of the teeter member 268 and extends downwardly therefrom to pivotally connect with the left U-bracket 276, which is rigidly connected with the left swing link 164 near the upper pivot 170. The right interconnecting link 272 is pivotally connected with a right portion 282 of the teeter member 268 and extends downwardly therefrom to pivotally connect with the right U-bracket 274, which is rigidly connected with the right swing link 158 near the upper



pivot 170. When either of the swing links swing rearward, the associated U-bracket pivots downwardly. The downward pivot of the U-bracket causes the teeter portion connected therewith (via the interconnection link) to pivot downwardly about the teeter axle. In coordination, the other portion of the teeter pulls upwardly on the other U-bracket. The upward force on the opposite U-bracket acts to swing the opposing swing link forwardly. In this way, the motion of the swing link and other links connected thereto, is coordinated via the interconnection assembly.

As shown in Fig. 9, the right and left interconnection links (270, 272) may include a threaded member 284 adapted to receive threaded eye-bolts 286 in opposing ends. Thus, in one implementation, the interconnecting links may be considered turnbuckles, through which rotation of the threaded member may be shortened or lengthened. The eye-bolts are adapted to rotatably receive interconnection link axes. The pivotal connections between the teeter, turnbuckles, and the U-brackets may be a ball joint or a universal joint configuration, in one implementation. Although the teeter axle is connected with the front post a location above the upper pivot, it is to be appreciated that in other embodiments of the interconnection assembly, the teeter axle may be connected with the front post a location below the upper pivot, as discussed below with reference to Fig. 15.

Fig. 10 is an isometric view of a second exercise device 100' conforming to the aspects of the present invention. Fig. 11 is a front view of the second exercise device 100', and Figs. 12A and 12B are right and left side views of the exercise device 100', respectively. The second exercise device, like the first embodiment, provides a user with a variable stride. Structurally, the second exercise device varies from the first in several ways. For example, in the second exercise device 100', the rear portions of the cam links are pivotally connected with the frame through guide links, as opposed to being supported by guide rollers engaged with rails, as discussed with reference to the first embodiment. In addition, the frame of the second embodiment is configured differently than the frame of the first embodiment.

As shown in Figs. 10-12B, the frame 102' includes a base portion 288, a front fork assembly 290, a rear fork assembly 292, a front post 294, and a handle bar assembly 296. The base portion 288 includes a base member 298 having a forward cross-member 300, a rearward cross-member 302, and a middle cross-member 304 connected therewith. The middle cross-member 304 may be connected with the base member at any location between the forward cross-member 300 and the rearward cross-member 302. The front fork assembly 290 and the rear fork assembly 292 connect with a portion of the base member 298 between

the forward cross-member and the middle cross-member. The front fork assembly 290 is defined by a right front fork member 306 and a left front fork member 308. The rear fork assembly 292 is defined by a right rear fork member 310 connected with a right crank suspension bracket 124', and a left rear fork member 312 connected with a left crank suspension bracket 128'.

As shown in Figs. 10-12B, a pulley 138' is rotatably connected with and between the right and left crank suspension brackets (124', 128') for rotation about the crank axle 144', which defines the crank axis 146'. Left and right crank arms (148', 150') are connected with the pulley 138' to rotate about the crank axis 146' along repeating circular paths 180 degrees out of phase with each other. The exercise device shown in Figs. 10-12B also includes a flywheel 140' rotatably connected with and between the right front fork member 306 and the left front fork member 308. The flywheel 140' is connected through a belt 156' with the pulley 138', although the pulley and flywheel may be connected through other means, such as a chain, a gear arrangement, direct interference drive, or the like.

The front fork assembly 290 extends upwardly and rearwardly from the base member 298 and connects with the rear fork assembly 292, which extends upwardly from the base member. The front post 294 extends upwardly and rearwardly from the intersection of the front and rear fork assemblies. The exercise device may also include a display panel 318 supported on the upper end portion of the front post.

Still referring to Figs. 10-12B, the handle bar assembly 296 includes a right handle bar 320 supported at a rearward portion 322 by a right upright member 324 extending upward from the middle cross-member 304, and a left handle bar 326 supported at a rearward portion 328 by a left upright member 330 extending upward from the middle cross-member 304. The right and left handle bars extend forward from the right and left upright members, curving downward and inward toward each other and intersecting at a forward handle bar point 332 located in front of the front post 294. A front support member 334 extends forwardly from the front post to connect with the front handle bar point. As previously mentioned, it is to be appreciated that various frame configurations and orientations can be utilized with the present invention other than what is depicted and described herein.

Similar to the first embodiment, and as shown in Fig. 12A, the right linkage assembly 106' includes a right swing link 158', a right cam link 160', and a right foot link 162' operatively connected with the right crank arm 150' and the frame 102' to provide a variable stride path. The left linkage assembly 104' is substantially a mirror image of the right linkage

assembly 106', and as shown in Fig. 12B, includes a left swing link 164', a left cam link 166', and a left foot link 168' operatively connected with the left crank arm 148' and the frame 102' to provide a variable stride path. The components of the linkage assemblies are connected with each other and interact with the right and left crank arms in a manner similar to that described above with reference to Figs. 1-9.

In contrast to the first embodiment, the rear portions (194', 198') of the cam links (160', 166') shown in Figs. 12A-12B are not coupled with the frame through guide rollers. Instead, the right cam link 160' is pivotally connected with a right guide link 336, which is pivotally connected with the right handle bar 320 at a right rear pivot 338. Similarly, the left cam link 166' is pivotally connected with a left guide link 340, which is pivotally connected with the left handle bar 326 at a left rear pivot 342. As such, the guide links pivot back and forth around the rear pivots when the exercise device is in use. Therefore, the pivotal connections between the cam links and the guide links move through arcs having radii defined by the lengths of the guide links. The guide rollers of the first embodiment roll along a flat, straight path; thus, the foot path shape will differ between the first embodiment and the second embodiment. Because alternative rail shapes are possible, the first embodiment may be configured to provide a foot path very similar to the second exercise device. Although the guide links depicted in Figs. 12A and 12B define substantially straight lengths, it is to be appreciated that other embodiments of the present invention can utilize guide links defining other shapes, such as arcuate or bent (so as to define an angle between straight end portions).

As shown in Figs. 10-12B, and as discussed above with reference to Figs. 1A-2, the exercise device 100' may also include lever arms (234', 236') connected with the swing links (158', 164'), which provide an extra gripping surface for the user as well as allowing the user to complement his use of the exercise device with an upper body workout. The lever arms are connected with upper portions of the swing links and extend upwardly to provide hand grips for a user. The lever arms shown in Figs. 10-12B are curved with a section 344 extending rearward and a section 346 extending upward. The rearward section orients the grip proximate a user standing on the foot pads (186', 187').

Similar to the first embodiment shown in Figs. 1A-2, the right and left foot links (162', 168') in the second embodiment in Figs. 10-12B include foot engaging portions (184', 185') located on the rearward portions of the foot links. The right and left foot engaging portions (184', 185') may also include rectangular right and left foot pads (186', 187') meant to support a user's foot. As previously mentioned, the foot engaging portions may be directly

connected with the top of the foot links or may be pivotally supported so that they articulate during use or their angular relations with the foot links vary. Additionally, the foot pads may be parallel with the links or any angle therebetween.

Portions of the foot links (162', 168'), between the forward and rearward ends thereof, are pivotally connected with portions of the cam links (160', 166') at cam link pivots (188', 190'). The cam members (204', 208') are connected with forward portions (206', 210') of the cam link, and each cam member includes a downwardly concave section 212' defining a generally arcuate surface 214'. The cam members (204', 208') are supported on cam rollers (152', 154') at the end of the crank arms (150', 148'). The cam rollers are adapted to rollingly support the arcuate cam surface of the cam members.

Because the cam member (204', 208') is not in fixed engagement with the crank arm (150', 148'), the exercise device includes features to keep the cam member from disengaging from the crank arm. One such feature is a bottom guide 348 connected with the cam links (160', 166'). The bottom guide, in one example, includes a tubular member 350 extending in an arc from a front 352 of the cam surface 214 to a rear 354 of the cam surface 214. The arc is generally parallel with the arc defined by the cam member. Additionally, the tubular member is below the arcuate surface slightly more than the diameter of the cam roller (152', 154'). As such, the roller is free to roll back-and-forth along the cam surface, but should the cam link lift up, the roller will bump against the bottom guide prohibiting it from disengaging. It is to be appreciated that other configurations may also be used to constrain the cam rollers. For example, the cam member is tubular defining a lower radius. The outer rolling surface 256 of the cam rollers defines a concave cross section adapted to engage the tubular-shaped cam member to help keep the cam rollers aligned with the cam members, and help prevent lateral disengagement as well as smooth back-and-forth rolling.

As with the first embodiment, the cam links (160', 166') are not constrained in fixed relation to the crank arms (150', 148'), but instead may move relative to the crank arms as the cam members (204', 208') move back and forth on the cam rollers (152', 154'). Thus, the paths in which the cam links and foot links move are variable and can be affected by the stride length of the user. Moreover, similar to the first embodiment, the paths in which the foot links (162', 168') and cam links (160', 166') move are not solely dictated by the geometric constraints of the swing links (158', 164'), the crank arms (150', 148'), and the frame 102'. Therefore, the user can dynamically adjust the travel path of the of the foot engaging section while using the exercise device based on the user's stride length and

variable forces imparted on the linkages. As described with the first embodiment, the cam links (160', 166') in the second embodiment act as variable stride links that allow a user to move the foot links by varying his stride length, stride power, stride frequency, or combinations thereof. Additionally, because all users naturally have different strides due to size, fitness, or desired exercise exertion, the exercise device conforms to all of these differences.

The user operates the exercise machine shown in Fig. 10 in the same manner as described above with reference to Figs. 1A-2. As such, a user first places his feet in operative contact with the right and left foot engagement portions (184', 186'). The user then exercises by striding forwardly toward the front post 294 with one leg and away with the other leg. Forces imparted to the foot engaging portion as well as the lever arms (234', 236') by the user cause the foot links (162', 168') to move back and forth, which in turn cause the swing links (158', 164') to pivot back and forth around the upper pivot 170'. At the same time, the crank arms (150', 148') rotate around the crank axis 146'. Because the foot links and the cam links are operatively connected with the frame 102' and the crank arms through the guide links (336, 340) and cam rollers in a partially unconstrained manner, the paths in which the cam links and foot links move are variable and can be affected by the stride of the user. As such, the paths in which the foot links and cam links move are not solely dictated by the geometric constraints of the swing links, the crank arms, and the frame. Therefore, the user can dynamically adjust the travel path of the of the foot engaging sections while using the exercise device. Thus, the exercise device provides a foot path that conforms to any particular user stride.

As the exercise device is in use, the relative motions of the members of the linkage assemblies (106', 104') and the crank arms (150', 148') of the second embodiment 100' of the second exercise device are similar to the first embodiment. However, the rear portions (194', 198') of the cam links (160', 166') shown in Figs. 10-12B do not travel back and forth along rails, but instead pivot about the rear pivots in an arc defined by the location of the connection between the guide links (336, 340) and the cam links (160', 166') from the rear pivots, and the lengths of the guide links. For further illustration, Figs. 12A-15B show the relative movement of the various components of the linkage assemblies of the second embodiment of the exercise device as the right crank arm moves from a rearward position to an upward position.

As shown in Figs. 12A and 12B, the right and left foot pads (186', 187') are oriented such that the user's right foot is placed rearwardly of his left foot. In addition, the user's right foot is positioned such that the user's right heel is raised relative to the user's right toes, and the user's left foot is positioned such that the user's left heel is lower relative to the user's left toes. The linkage assemblies (104', 106') illustrated in Figs. 12A and 12B also depict an orientation associated with a lengthened stride, such as may occur during more vigorous exercise. Thus, the right cam link 160' is in its rearward-most position and the left cam link 166' is its forward-most position. To orient the right cam link 160' in its rearward-most position, the right cam roller 152' is engaged with the downwardly extending portion of the cam surface at the forward end 200' of the right cam member 204'. To orient the left cam link 166' in its rearward-most position, the left cam roller 154' is engaged with the downwardly extending portion of the cam surface located at the rearward end 222' of the left cam member 208'. Therefore, the foot pads (186', 187') illustrated in Figs. 12A and 12B are separated by a greater distance than the foot pads would be if the cam rollers were located on the apex 232' of each cam surface for the same crank arm orientation.

As the user strides forward toward the front post 294, the right crank arm 150' rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146' from the rearward orientation shown in Figs. 12A and 12B toward an orientation shown in Figs. 13A and 13B, which causes the lower portion 174' of the right swing link 158' to pivot counterclockwise from a rearward position shown in Fig. 12A around the upper pivot 170' to a position shown in Fig. 13A. At the same time, the right guide link 336 pivots counterclockwise about the right rear pivot 338. In addition, the left crank arm 148' rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146' from the forward orientation shown in Fig. 12B toward the orientation shown in Fig. 13B, which causes the lower portion 175' of the left swing link 164' to pivot clockwise from a rearward position shown in Fig. 12B around the position shown in Fig. 13B. At the same time, the left guide link 340 pivots clockwise about the left rear pivot 342. The flywheel 140' helps rotate the crank arms smoothly, which is important because the crank arms are not directly connected with the linkage assemblies.

As shown in Figs. 13A and 13B, the right foot pad 186' has moved upward and forward from the position shown in Fig. 12A, and the left foot pad 187' has moved downward and rearward from the position shown in Fig. 12B. Thus, the foot pads (186', 187') are closer together in Figs. 13A and 13B. Additionally, in Figs. 13A and 13B, the right and left pads are oriented such that the user's right foot is placed upward and rearward relative to his left

foot. The right cam roller 152' has also moved rearward relative to the right cam member 204' toward the apex 232' of the right cam surface, and the left cam roller 154' has moved forward relative to the left cam member 208' toward the apex 232' of the left cam surface. In addition, the user's right foot is positioned such that the user's right heel is raised relative to the user's right toes, and the user's left foot is positioned such that the user's left heel is also lower relative to the user's left toes. As the user continues to stride forward toward the front post 294, the right crank arm 150' rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146' from the orientation of Fig. 13A to the orientation of Fig. 14A, which is accompanied by the lower portion of the right swing link 158' pivoting counterclockwise from the position shown in Fig. 13A around the upper pivot 170' to a position shown in Fig. 14A. At the same time, the right guide link 336 continues to pivot counterclockwise about the right rear pivot 338. In addition, the left crank arm 148' rotates in a clockwise direction (as viewed from the right side of the exercise device) around the crank axis 146' from the orientation of Fig. 13B downward to the orientation of Fig. 14B, which is accompanied by the lower portion 175' of the left swing link 164' pivoting clockwise from the position shown in Fig. 13B around the upper pivot 170' to the position shown in Fig. 14B. At the same time, the left guide link 340 continues to pivot clockwise about the left rear pivot 342.

As shown in Figs. 14A and 14B, the right foot pad 186' has moved upward and forward from the position shown in Fig. 13A, and the left foot pad 187' has moved downward and rearward from the position shown in Fig. 13B. Thus, the foot pads are closer together in Figs. 14A and 14B. Additionally, in Figs. 14A and 14B, the right and left pads are oriented such that the user's right foot is placed upward relative to his left foot. The right cam roller 152' has also moved rearward relative to the right cam member 204' near the apex 232' of the right cam surface, and the left cam roller 154' has moved forward relative to the left cam member 208' near the apex 232' of the left cam surface. In addition, the user's right foot is positioned such that the user's right heel is raised relative to the user's right toes, and the user's left foot is positioned such that the user's left heel is almost level with the user's left toes.

It is to be appreciated that varying the length and/or shape of the guide links (336, 340), foot links (162', 168'), swing links (158', 164'), cam links (160', 166'), and the contours of the cam surfaces may affect how the foot engaging pads (186', 187') move for varying stride lengths. For example, the pivoting motion of the guide link alone or in combination with the swing path of the cam link may cause the foot pad to move in a manner similar to a

user's ankle articulation at the rear of a user's natural stride, wherein the user's heel is raised relative to the user's toes. Similarly, the pivoting motion of the guide link alone or in combination with the swing path of the cam link may cause the foot pad to transition to and move in a manner similar to a user's ankle articulation at the front of a user's natural stride, wherein the user's heel is lower relative to the user's toes. Further, guide links and cam surfaces may be configured to imitate a user's ankle articulation for longer and shorter strides. For example, a user's heel may be raised to a higher elevation relative to his toes at the rear of the user's longer stride as compared to the user's shorter stride. Similarly, a user's heel may be lowered to a lower elevation relative to his toes at the front of the user's longer stride as compared to the user's shorter stride. In most instances, providing a foot pad that articulates in a manner similar to a user's ankle keeps the user's foot substantially in contact with the foot pad to reduce jarring impacts associated when a user's foot loses then gains contact with the foot engaging portion. In addition, other embodiments of the exercise device can utilize various lengths and shapes of guide links and cam surfaces so as to alter how the user's foot will move throughout a given stride length.

The second embodiment of the exercise device 100' shown in Fig. 10 also includes an interconnection assembly 266' that acts to move the linkage assemblies in opposite directions. A detailed view of the interconnection assembly 266' is shown in Fig. 15 and is structurally similar to the interconnection described above with reference to Fig. 9, except the teeter member is located below the upper pivot 170'. As such, the interconnection assembly 266' includes a teeter member 268', a right interconnection link 270', a left interconnection link 272', a right U-bracket 274', and a left U-bracket 276'. A teeter axle 278' extends forwardly from the front post 294 and is adapted to pivotally support the teeter member. The left interconnection link 272' is pivotally connected with the left portion 280' of the teeter member 268' and extends upwardly therefrom to pivotally connect with the left U-bracket 276', which is rigidly connected with the left swing link 164' near the upper pivot 170'. The right interconnecting link 270' is pivotally connected with the right portion 282' of the teeter member 268' and extends upwardly therefrom to pivotally connect with the right U-bracket 274', which is rigidly connected with the right swing link 158' near the upper pivot 170'. When either of the swing links (158', 164') swing rearward, the associated U-bracket (274', 276') of the interconnection assembly 266' shown in Fig. 15 pivots upwardly. More particularly, when the right swing link 158' rotates about the upper pivot 170' in a counterclockwise direction (as viewed from the right side of the exercise device), the right U-bracket 274' pulls (through the right interconnection link 270') the right portion 282' of the



teeter member 268' upwardly and causes the teeter to rotate clockwise around the teeter axle 278' (as viewed from the front of the exercise device). As the teeter member rotates clockwise (as viewed from the front of the exercise device), the left portion 280' of the teeter member pulls downwardly on the left U-bracket 276' (through the left interconnection link 272'), which in turn, causes the left swing link 164' to rotate about the upper pivot in a clockwise direction (as viewed from the right side of the exercise device).

Some embodiments of the present invention may include a motion limiter that acts to limit the movement of the cam members when a user begins exercising. More particularly, the motion limiter impedes excessive upward movement of the cams. For example, when a user begins exercise by imparting an initial movement to the foot links, which is translated to the cam members, depending on the relative positions of the various links, the cam members may move relative to the cam rollers in an upward and/or downward direction before the crank arms begin turning. Unless the initial upward movement of the cam members is limited to some degree, a user's initial stride movements may be awkward. In addition, the motion limiter prevents the cam from striking the inside of the shroud in embodiments of the exercise device that include a shroud enclosing the cam members, crank arms, pulley, and flywheel.

One example of a motion limiter 358 is shown in Figs. 16 and 17. The motion limiter includes a right limiter roller 360 and a left limiter roller 362 adjustably supported by a roller support member 364. The roller support member 364 is positioned above and forward the pulley 138'. The right and left limiter rollers (360, 362) are aligned in the same plane as the left and right cam rollers (152', 154'), respectively. A rear portion 366 of the roller support member 364 is adjustably connected with a rearward upright member 368. The rearward upright member is transversely connected with a forward extension member 370 extending from the front post 294. The rearward upright member 368 defines a slot 372 adapted to receive a rearward bolt and nut 374 connected with the roller support member 364. The rearward bolt and nut 374 allow the rear portion 366 of the roller support member 364 to be connected at any location along the length of the slot 372.

As shown in Figs. 16 and 17, a forward portion 376 of the roller support member 364 is adjustably connected with a forward upright member 378. The forward upright member 378 is pivotally connected with the forward cross member 300 of the base portion 288 of the frame 102'. The forward upright member 378 defines a slot 380 adapted to receive a forward bolt and nut 382 connected with the roller support member 364. The forward bolt and nut

allow the forward portion 376 of the roller support member 364 to be connected at any location along the length of the slot 380.

Still referring to Figs. 16 and 17, the roller support member 364 also defines a slot 384 adapted to receive a roller bolt and nut 386 that allows the right and left limit rollers (360, 362) to be connected at any location along the length the slot 384. The slotted connections between the various members and rollers of the motion limiter allow a user to optimally position the limit rollers to accommodate initial cam member movements and/or prevent the cam members from contacting the shroud (if used). It is to be appreciated that the motion limiter may include other hardware configurations, such as a pop-pin or spring loaded pin arrangement to allow for adjustment of the roller positions. Although the motion limiter shown in Figs. 16 and 17 is configured to allow for adjustment of the roller position, other embodiments of the present invention may include fixed position rollers.

Fig. 16 shows the exercise device 100' with the linkage assemblies (106', 104') in an initial position before a user imparts any motion to either foot link (162', 168'). If the user were to stride forward very quickly before the crank arms (150', 148') began to turn, the cams (204', 208') may hit the rollers (360, 362) and be forced to move forward with the cranks rather than continue moving upward. For example, as shown in Fig. 17, the right cam member 204' is shown in a forward and upward position relative to the position shown in Fig. 16 and is in contact with the right roller 360. Because the right roller 360 of the motion limiter 358 will prevent the right cam member 204' from continuing to travel upward, the right cam member shown in Fig. 17 will move forward with the right crank arm and right cam roller.

Other embodiments of the exercise device include a lockout device that allows a user to lock the swing links in position so as to prevent the swing links from pivoting about the upper pivot while exercising. The lockout device can be configured in various ways in order to lock the swing links in position. For example, in an exercise machine having any of the interconnection assemblies shown in Figs. 8, 9, or 15, preventing the teeter member from pivoting about the teeter axle would effectively lock the swing links in position. Pivotal movement of the teeter member could be prevented in a number of ways, such as by clamping the teeter member to the front post or inserting a pin through the teeter member and into the front post.

Figs. 18 and 19 depict one example of a lockout mechanism 388 used in conjunction with the interconnection assembly 266' described above with reference to Fig. 15. The

lockout mechanism 388 shown in Figs. 18 and 19 utilizes a pop-pin mechanism 390 to prevent the teeter member 268' from rotating about the teeter axle 278' on the front post 294. The lockout mechanism includes a locking plate 392 connected with and extending downward from the teeter member 268'. A first aperture 394 is located in a lower portion 396 of the locking plate 392. A U-bracket 398 is connected with and extends forward from the front post 294 far enough to place a top surface 400 of the U-bracket 398 in close proximity to the locking plate 392 while allowing the locking plate to pass unimpeded over the top of the U-bracket while the exercise device is in use. A second aperture 402 is located in the top surface 400 of the locking plate 392. The pop-pin mechanism 390 is connected with a pop-pin support structure 404 extending forward from the front post 294, which places a pin 406 extending from the pop-pin mechanism in alignment with the second aperture in the U-bracket.

The lockout mechanism 388 shown in Figs. 18 and 19 can be engaged to prevent the teeter member 268' from pivoting about the teeter axle 278' by first aligning the first aperture 394 above the second aperture 402, which are both adapted to receive the pin 406 from the pop-pin mechanism 390. Alignment of the apertures may be accomplished by manipulating the linkages of the exercise device. Next, the pin 406 is inserted through the first and second apertures (394, 402), as shown in Fig. 19, which prevents the locking plate 392 and the teeter member 268' from pivoting about the teeter axle 278'. Because the teeter member cannot pivot, the right and left swing links (158', 164') are prevented from pivoting about the upper pivot 170'. The lockout device 388 is disengaged from the interconnection assembly by removing the pin from the first and second apertures.

Using a lockout device to prevent the swing links from pivoting about the upper pivot alters the foot paths of the foot engaging portions of the foot links as the crank arms rotate in such a way as to resemble a stepping motion. To operate the exercise machine with the swing links locked in position, a user first places his feet in operative contact with the right and left foot engagement portions. The user then exercises by exerting a downward force on either the left or right foot engagement portions. Interaction of the reciprocating crank arms and the cam links cause the foot links to pivot up and down opposite from each other about the lower pivots.

In one example where a lockout device is used to prevent the swing links from pivoting about the upper pivot 170 (referring the exercise device in either Figs. 1A-2 or Figs. 10-12B), a downward force imparted to the right foot engaging portion 184 of the right foot

link 162 is transferred to the right cam link 160 through the right cam link pivot 188, which in turn, transfers forces to the right cam roller 152 and the right guide roller 192 (or right guide link). The downward force exerted on the right cam roller causes the right crank arm to rotate toward the 6 o'clock or downward position. As the right crank arm and right cam roller move toward the downward position, the right cam link pivots downward or clockwise (as viewed from the right side of the exercise device) about the right guide roller (or right rear pivot 336). Therefore, the right cam link pivot 188 moves downwardly with the right cam link 160, which in turn allows the right foot link 162 to move downward. Because the right swing link 158 is held in a fixed position relative to the upper pivot 170, the range of motion of the right foot link 162 is limited to pivoting about the right lower pivot 178. As such, the right foot engaging portion 184 and the right cam link pivot 188 both pivot clockwise about the right lower pivot 178.

At the same time the right crank arm 150 rotates toward the downward position, the left crank arm 148 rotates toward the 12 o'clock or upward position. As the left crank arm and left cam roller 154 move toward the upward position, the left cam link 166 pivots upward or counterclockwise (as viewed from the right side of the exercise device) about the left guide roller 196 (or left rear pivot 342). Therefore, the left cam link pivot 190 moves upwardly with the left cam link 166, which in turn pushes the left foot link upward 168. Because the left swing link 164 is held in a fixed position relative to the upper pivot 170, the range of motion of the left foot link 168 is limited to pivoting about the left lower pivot 179. As such, the left foot engaging portion 185 and the left cam link pivot 190 both pivot counterclockwise (as viewed from the right side of the exercise device) about the left lower pivot 179. The above described motions of the right and left foot links can be repeated to perform a stepping-type exercise.

It will be appreciated from the above noted description of various arrangements and embodiments of the present invention that a variable stride exercise device has been described which includes first and second linkage assemblies, first and second crank arms, and a frame. The exercise device can be formed in various ways and operated in various manners depending upon on how the linkage assemblies are constructed and coupled with the frame. It will be appreciated that the features described in connection with each arrangement and embodiment of the invention are interchangeable to some degree so that many variations beyond those specifically described are possible. For example, in any of the embodiments described herein, the crank arms may be operatively connected with a motor, a flywheel, an

electromagnetic resistance device, performance feedback electronics and other features or combination thereof.

Although various representative embodiments of this invention have been described above with a certain degree of particularity, those skilled in the art could make numerous alterations to the disclosed embodiments without departing from the spirit or scope of the inventive subject matter set forth in the specification and claims. All directional references (e.g., upper, lower, upward, downward, left, right, leftward, rightward, top, bottom, above, below, vertical, horizontal, clockwise, and counterclockwise) are only used for identification purposes to aid the reader's understanding of the embodiments of the present invention, and do not create limitations, particularly as to the position, orientation, or use of the invention unless specifically set forth in the claims. Joinder references (e.g., attached, coupled, connected, and the like) are to be construed broadly and may include intermediate members between a connection of elements and relative movement between elements. As such, joinder references do not necessarily infer that two elements are directly connected and in fixed relation to each other.

In some instances, components are described with reference to "ends" having a particular characteristic and/or being connected with another part. However, those skilled in the art will recognize that the present invention is not limited to components which terminate immediately beyond their points of connection with other parts. Thus, the term "end" should be interpreted broadly, in a manner that includes areas adjacent, rearward, forward of, or otherwise near the terminus of a particular element, link, component, part, member or the like. In methodologies directly or indirectly set forth herein, various steps and operations are described in one possible order of operation, but those skilled in the art will recognize that steps and operations may be rearranged, replaced, or eliminated without necessarily departing from the spirit and scope of the present invention. It is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not limiting. Changes in detail or structure may be made without departing from the spirit of the invention as defined in the appended claims.

## CLAIMS

What is claimed is:

1. An exercise device comprising:
  - a frame;
  - at least one swing link pivotally connected with said frame;
  - at least one crank arm pivotally connected with said frame and configured to rotate about a crank axis;
  - at least one variable stride link supported by said at least one crank arm and said frame, said at least one variable stride link coupled with said at least one crank arm to allow relative movement between said at least one variable stride link and said at least one crank arm along a first portion of said at least one variable stride link; and
  - at least one foot link pivotally connected with said at least one swing link and said at least one variable stride link.
2. The exercise device of claim 1, further comprising:
  - a second swing link pivotally connected with said frame;
  - a second crank arm pivotally connected with said frame and configured to rotate about said crank axis;
  - a second variable stride link supported by said second crank arm and said frame, said second variable stride link coupled with said second crank arm to allow relative movement between said second variable stride link and said second crank arm along a second portion of said second variable stride link; and
  - a second foot link pivotally connected with said second swing link and said second variable stride link.
3. The exercise device of claim 1, wherein said at least one variable stride link is a cam link including at least one cam member.
4. The exercise device of claim 3, wherein said at least one cam member defines an arcuate surface.
5. The exercise device of claim 4, wherein said arcuate surface is defined by a constant radius.
6. The exercise device of claim 4, wherein said arcuate surface is defined by a variable radius.
7. The exercise device of claim 3, wherein said at least one crank arm includes at least one cam roller adapted to engage said at least one cam member.

8. The exercise device of claim 1, wherein said frame includes at least one rail, and wherein said at least one variable stride link includes at least one guide roller adapted to engage said at least one rail.
9. The exercise device of claim 8, wherein said at least one rail is flat.
10. The exercise device of claim 8, wherein said at least one rail is declined.
11. The exercise device of claim 8, wherein said at least one rail is inclined.
12. The exercise device of claim 8, wherein said at least one rail is arcuate.
13. The exercise device of claim 1, further comprising at least one lever arm connected with said at least one swing link.
14. The exercise device of claim 1, further comprising at least one guide link pivotally connected with said frame and pivotally connected with said at least one variable stride link.
15. An exercise device comprising:
  - a frame;
  - a first member and a second member pivotally coupled with said frame;
  - a first arm reciprocally coupled with said frame;
  - a second arm reciprocally coupled with said frame;
  - a third member movingly supported by said first arm and said frame;
  - a fourth member movingly supported by said second arm and said frame;
  - a fifth member pivotally coupled with said first member and said third member; and
  - a sixth member pivotally coupled with said second member and said fourth member.
16. The exercise device of claim 15, wherein said first arm comprises a first crank arm and said second arm comprises a second crank arm, and wherein said first crank arm and said second crank arm are pivotally connected with said frame and configured to rotate about a crank axis.
17. The exercise device of claim 15, wherein said third member comprises a first variable stride link, and said fourth member comprises a second variable stride link.
18. The exercise device of claim 17, wherein said first variable stride link comprises a first cam link including a first cam member, and said second variable stride link comprises a second cam link including a second cam member.
19. The exercise device of claim 18, wherein said first arm supports a first cam roller adapted to engage said first cam member, and said second arm supports a second cam roller adapted to engage said second cam member.
20. The exercise device of claim 19, wherein said first cam member defines a first arcuate surface, and said second cam member defines a second arcuate surface.

21. The exercise device of claim 20, wherein said first cam roller rollingly reciprocates along said first arcuate surface, and said second cam roller rollingly reciprocates along said second arcuate surface.
22. The exercise device of claim 21, wherein said first arcuate surface and said second arcuate surface are defined by a constant radius.
23. The exercise device of claim 21, wherein said first arcuate surface and said second arcuate surface are defined by a variable radius.
24. The exercise device of claim 17, wherein said frame includes a first rail and a second rail, wherein said first variable stride link includes a first guide roller adapted to engage said first rail, and said second variable stride link includes a second guide roller adapted to engage said second rail.
25. The exercise device of claim 24, wherein said first rail and said second rail are flat.
26. The exercise device of claim 24, wherein said first rail and said second rail are declined.
27. The exercise device of claim 24, wherein said first rail and said second rail are inclined.
28. The exercise device of claim 24, wherein said first rail and said second rail are arcuate.
29. The exercise device of claim 24, wherein said first guide roller rollingly reciprocates along said first rail, and said second guide roller rollingly reciprocates along said second rail.
30. The exercise device of claim 15, wherein said fifth member comprises a first foot link, and said sixth member comprises a second foot link.
31. The exercise device of claim 30, further comprising an interconnection mechanism operably connecting said first foot link with said second foot link such that movement of said first foot link in a first direction is coordinated with movement said second foot link in a second direction opposite of said first direction.
32. The exercise device of claim 31, wherein said interconnection mechanism comprises a cable passing over at least one pulley, said cable connecting said first variable stride link with said second variable stride link.
33. The exercise device of claim 31, wherein said interconnection mechanism comprises:
  - a teeter member pivotally coupled with said frame;
  - a first interconnection link pivotally coupled with said first member and said teeter member;



a second interconnection link pivotally coupled with said second member and said teeter member.

34. The exercise device of claim 15, wherein said first member comprises a first swing link, and said second member comprises a second swing link.

35. The exercise device of claim 34, further comprising a first arm exercise member coupled with said first swing link, and a second arm exercise member connected with said second swing link.

36. The exercise device of claim 35, wherein said first arm exercise member extends from said first swing link, and said second arm exercise member extends from said second swing link.

37. The exercise device of claim 15, further comprising a lockout means for selectively holding said fifth member and said sixth member in fixed positions relative to said frame.

38. An exercise device comprising:

- a frame;
- a first swing link and a second swing link pivotally connected with said frame;
- a first guide link and a second guide link pivotally connected with said frame;
- a first crank arm and a second crank arm pivotally connected with said frame and configured to rotate about a crank axis;
- a first variable stride link rollingly supported by said first crank arm and pivotally connected with said first guide link;
- a second variable stride link rollingly supported by said second crank arm and pivotally connected with said second guide link;
- a first foot link pivotally connected with said first swing link and said first variable stride link; and
- a second foot link pivotally connected with said second swing link and said second variable stride link.

39. The exercise device of claim 38, wherein said first variable stride link is a first cam link including a first cam member, and said second variable stride link is a cam link including a second cam member.

40. The exercise device of claim 39, wherein said first cam member defines a first arcuate surface, and said second cam member defines a second arcuate surface.

41. The exercise device of claim 40, wherein said first arcuate surface and said second arcuate surface are defined by a constant radius.

42. The exercise device of claim 40, wherein said first arcuate surface and said second arcuate surface are defined by a variable radius.
43. The exercise device of claim 39, wherein said first crank arm includes a first cam roller adapted to engage said first cam member, and said second crank arm includes a second cam roller adapted to engage said second cam member.
44. The exercise device of claim 38, wherein said frame includes a handle bar assembly, wherein said first guide link and said second guide link are pivotally connected with said handle bar assembly.
45. The exercise device of claim 38, further comprising an interconnection mechanism operably connecting said first foot link with said second foot link such that movement of said first foot link in a first direction moves said second foot link in a second direction opposite of said first direction.
46. The exercise device of claim 45, wherein said interconnection mechanism comprises a cable passing over at least one pulley, said cable connecting said first variable stride link with said second variable stride link.
47. The exercise device of claim 45, wherein said interconnection mechanism comprises:  
a teeter member pivotally connected with said frame;  
a first interconnection link pivotally connected with said first swing link and said teeter member;  
a second interconnection link pivotally connected with said second swing link and said teeter member.
48. The exercise device of claim 38, further comprising a first lever arm connected with said first swing link, and a second lever arm connected with said second swing link.
49. The exercise device of claim 38, further comprising a lockout means for selectively holding said first swing link and said second swing link in fixed positions relative to said frame.
50. An exercise device comprising:  
a frame;  
a first member and a second member pivotally coupled with said frame;  
a first arm reciprocally coupled with said frame;  
a second arm reciprocally coupled with said frame;  
a third member movingly supported by said first arm and said frame;  
a fourth member movingly supported by said second arm and said frame;  
a fifth member pivotally coupled with said first member and said third member;

a sixth member pivotally coupled with said second member and said fourth member;  
and

an interconnection assembly operably coupling movement of said first member, said first arm, said third member, and said fifth member with movement of said second member, said second arm, said fourth member, and said sixth member.

51. The exercise device of claim 50, wherein said first arm comprises a first crank arm and said second arm comprises a second crank arm, and wherein said first crank arm and said second crank arm are pivotally connected with said frame and configured to rotate about a crank axis.

52. The exercise device of claim 50, wherein said third member comprises a first variable stride link, and said fourth member comprises a second variable stride link.

53. The exercise device of claim 52, wherein said first variable stride link comprises a first cam link including a first cam member, and said second variable stride link comprises a second cam link including a second cam member.

54. An exercise device comprising:

- a frame defining a front portion and a rear portion;
- a crank assembly supported on said front portion of said frame;
- a left linkage assembly comprising at least three members variably coupled with said crank assembly; and
- a left linkage assembly comprising at least three members variably coupled with said crank assembly.

55. The exercise device of claim 54, wherein said left linkage assembly is reciprocally supported on said rear portion of said frame, and wherein said right linkage assembly is reciprocally supported on said rear portion of said frame.

56. The exercise device of claim 55, further comprising:

- a left linkage to reciprocally support said left linkage assembly at said rear portion of said frame; and
- a right linkage to reciprocally support said right linkage assembly at said rear portion of said frame.

57. The exercise device of claim 55, further comprising:

- a left roller to reciprocally support said left linkage assembly at said rear portion of said frame; and
- a right roller to reciprocally support said right linkage assembly at said rear portion of said frame.

58. An exercise device comprising:  
a frame;  
a frame defining a front portion and a rear portion;  
a left means for providing a variable foot path; and  
a right means for providing a variable foot path;  
said left means and said right means supported on said frame.
59. The exercise device of claim 58, further comprising:  
a left cam means for variably supporting said left means; and  
a right cam means for variably supporting said right means.
60. The exercise device of claim 59, further comprising:  
a left crank for supporting said left cam means; and  
a right crank for supporting said right cam means.
61. The exercise device of claim 58, further comprising a means for interconnecting said left means and said right means such that movement of said left means in a first direction moves said right means in a second direction opposite of said first direction.
62. The exercise device of claim 58, further comprising a first handle means connected with said left means, and a second handle means connected with said right means.
63. The exercise device of claim 58, further comprising a lockout means for selectively holding said left means and said right means in fixed positions relative to said frame.

1/31

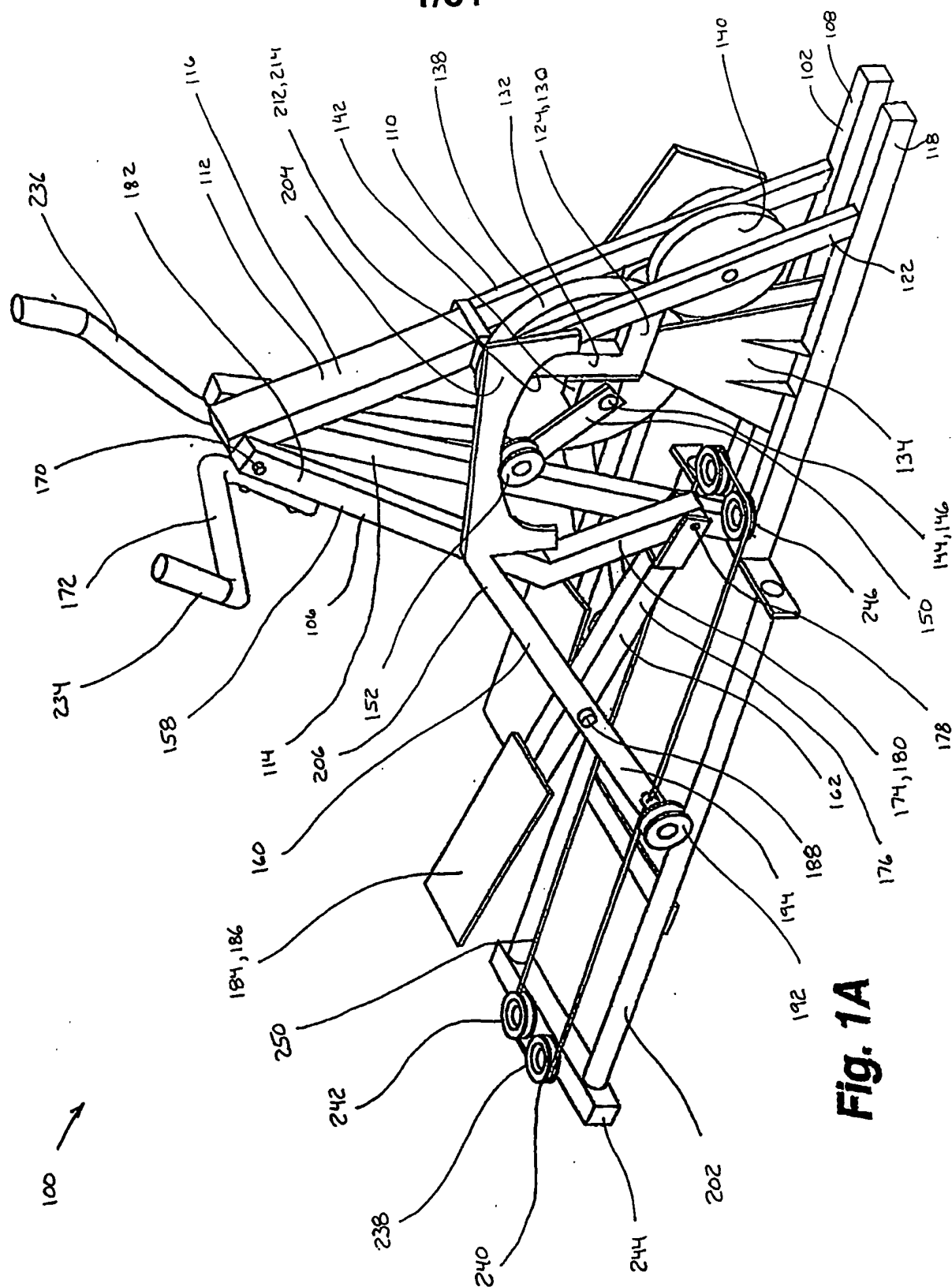
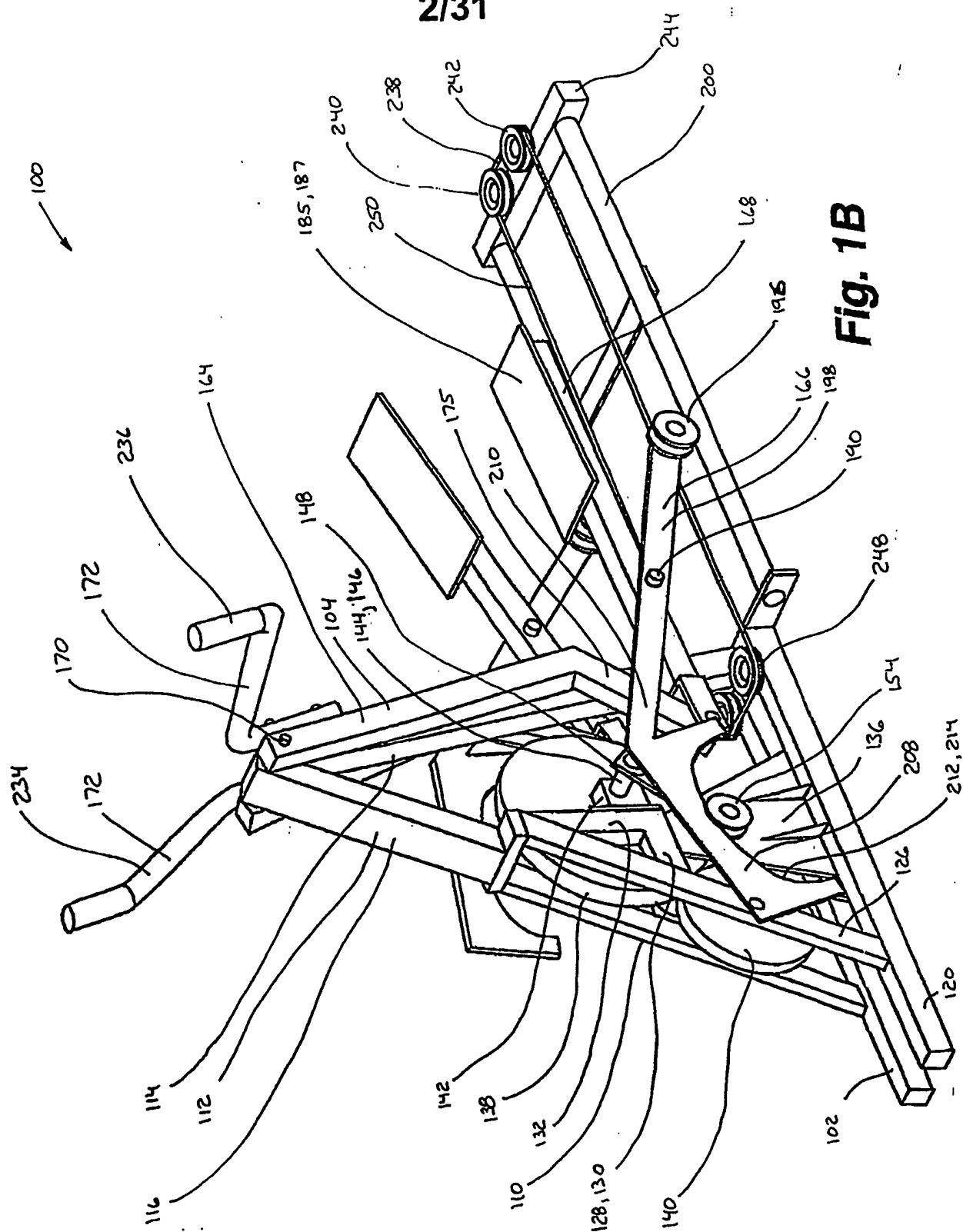
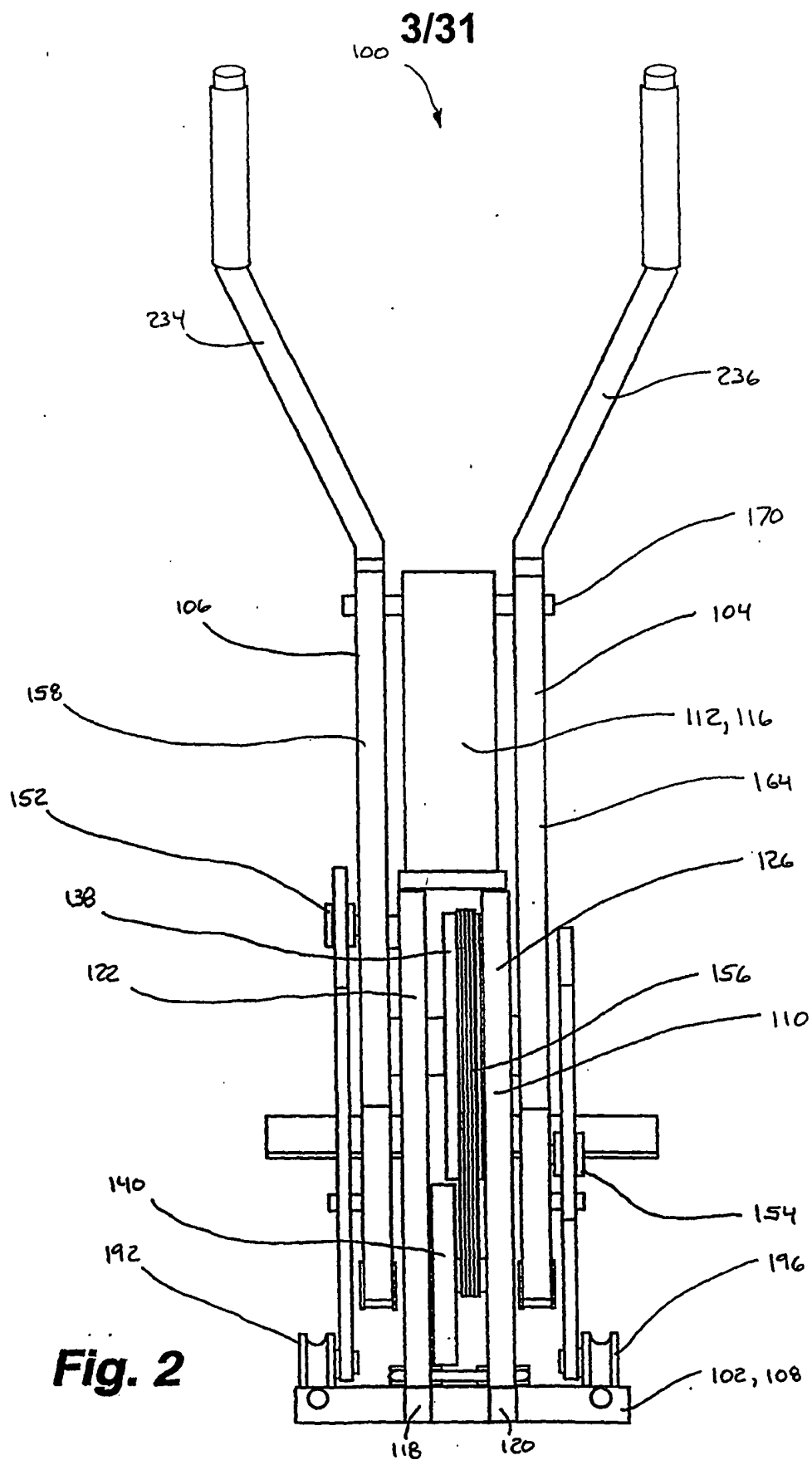


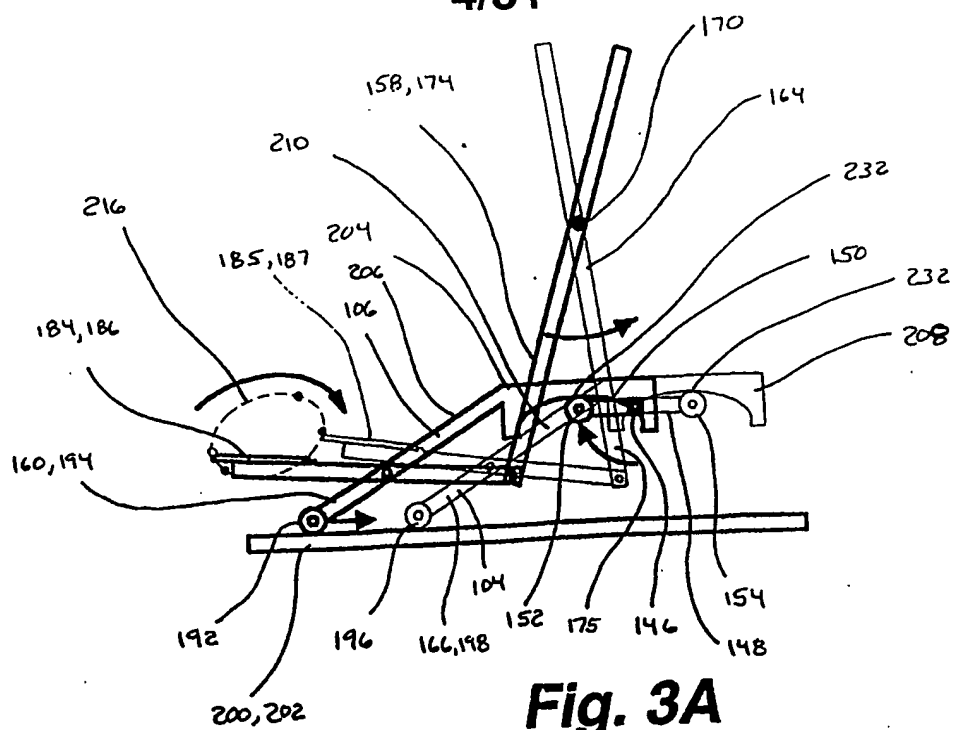
Fig. 1A



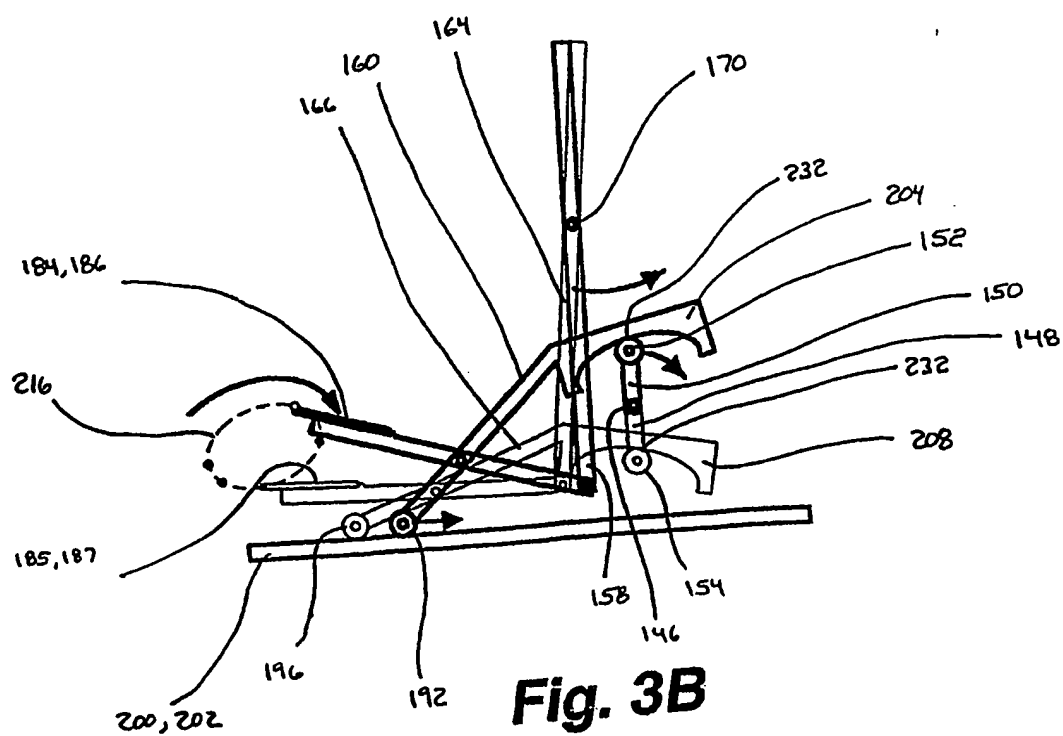
**Fig. 1B**



4/31



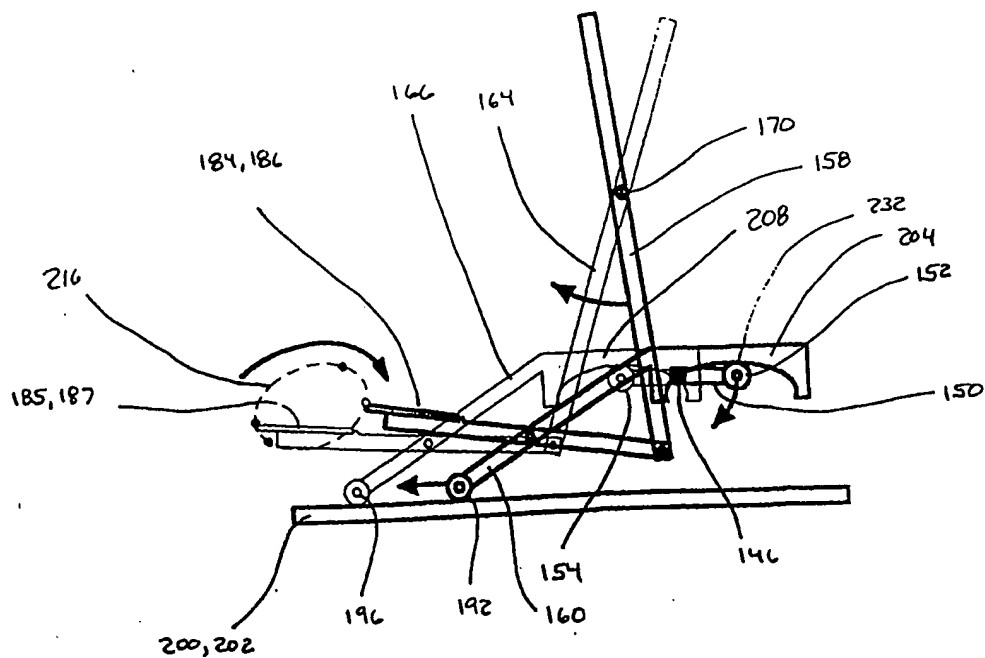
**Fig. 3A**



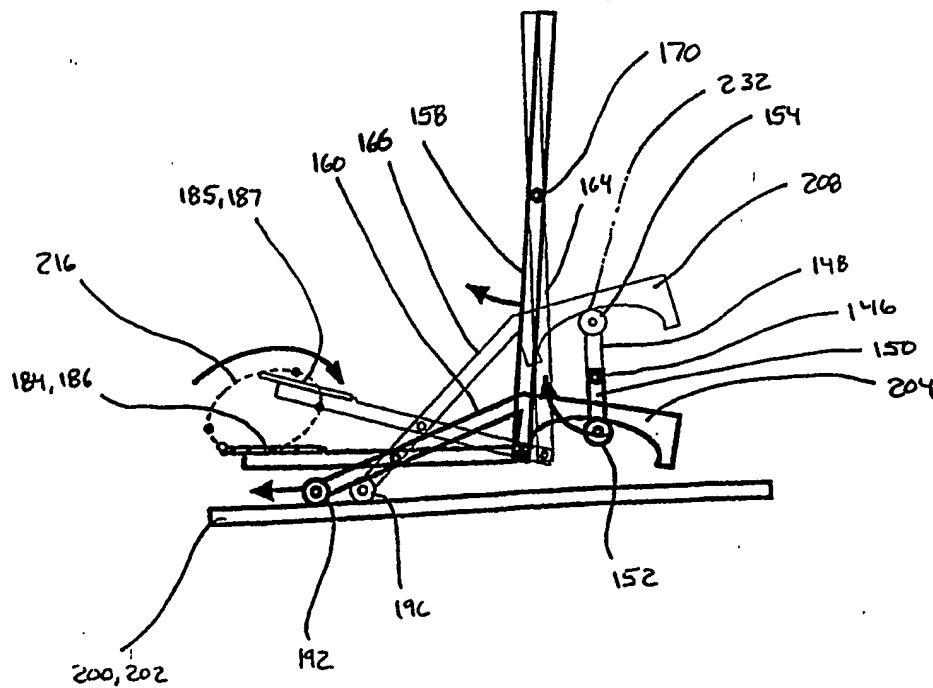
**Fig. 3B**



5/31

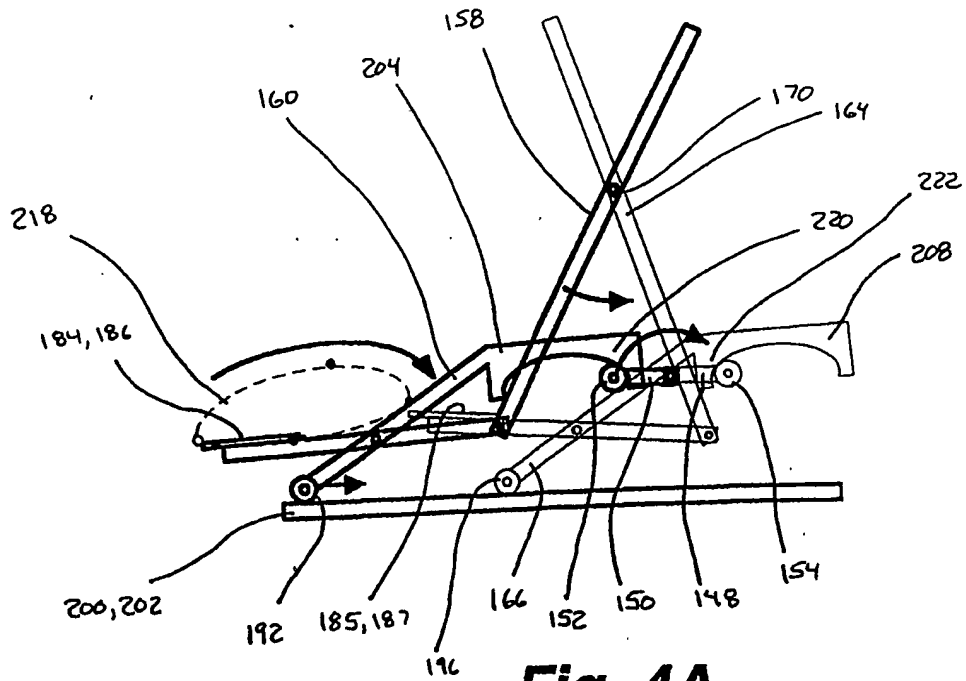


**Fig. 3C**

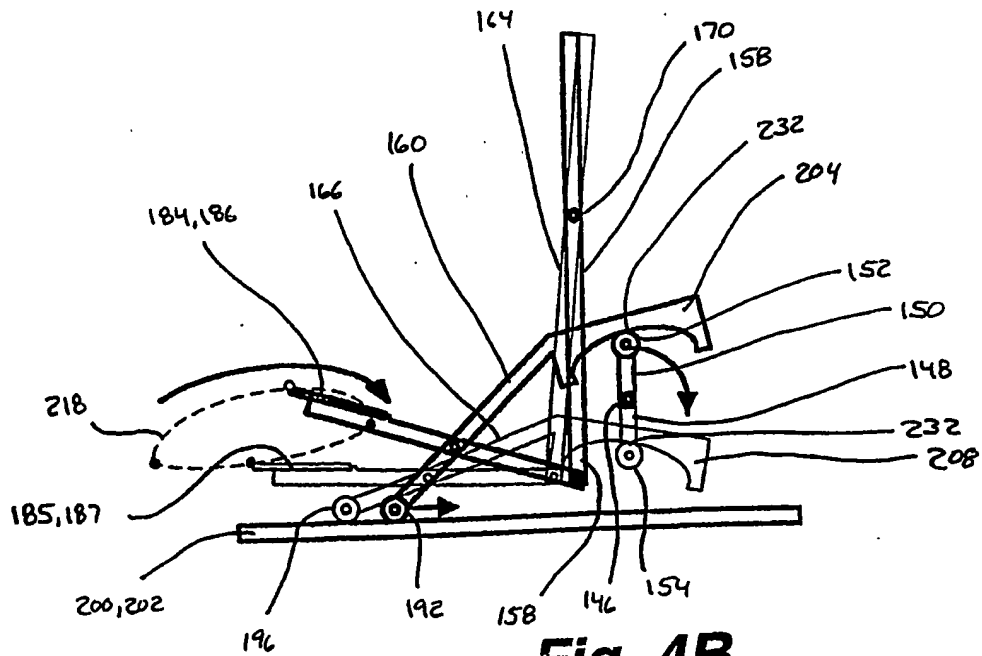


**Fig. 3D**

6/31

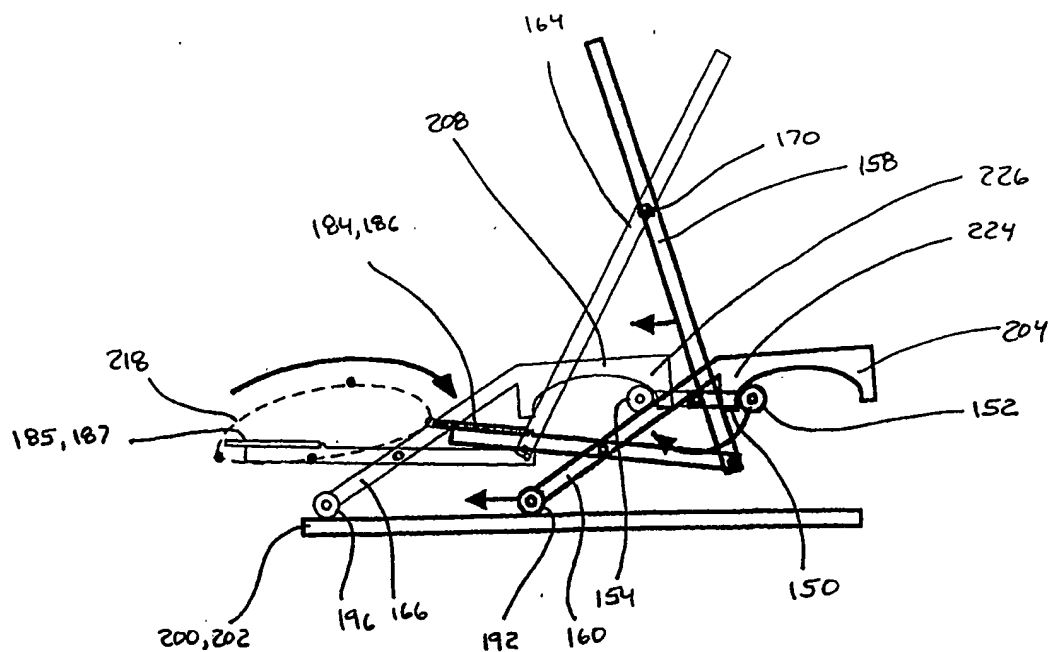


**Fig. 4A**

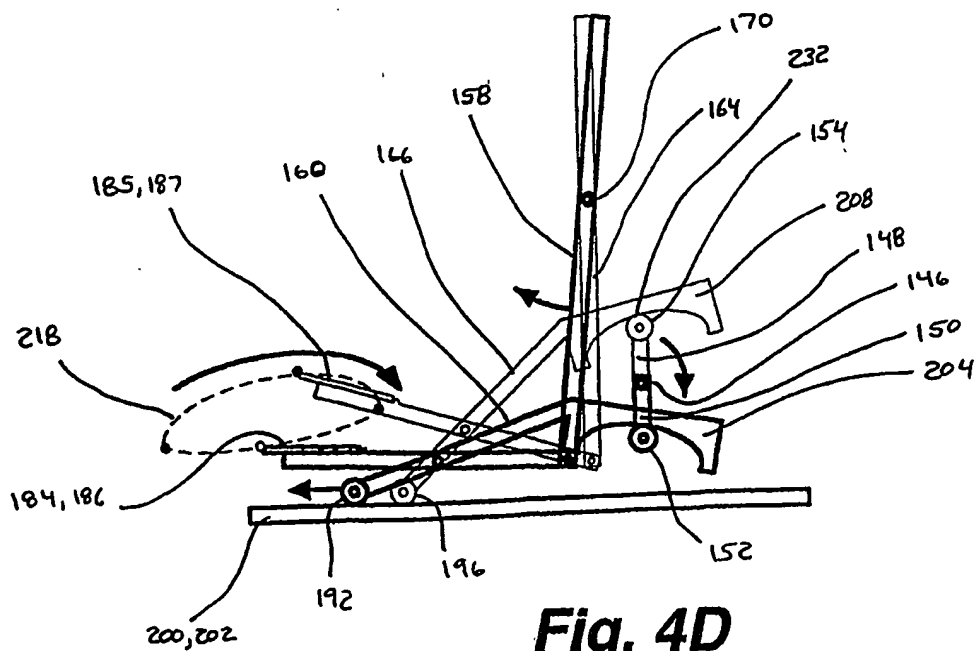


**Fig. 4B**

7/31

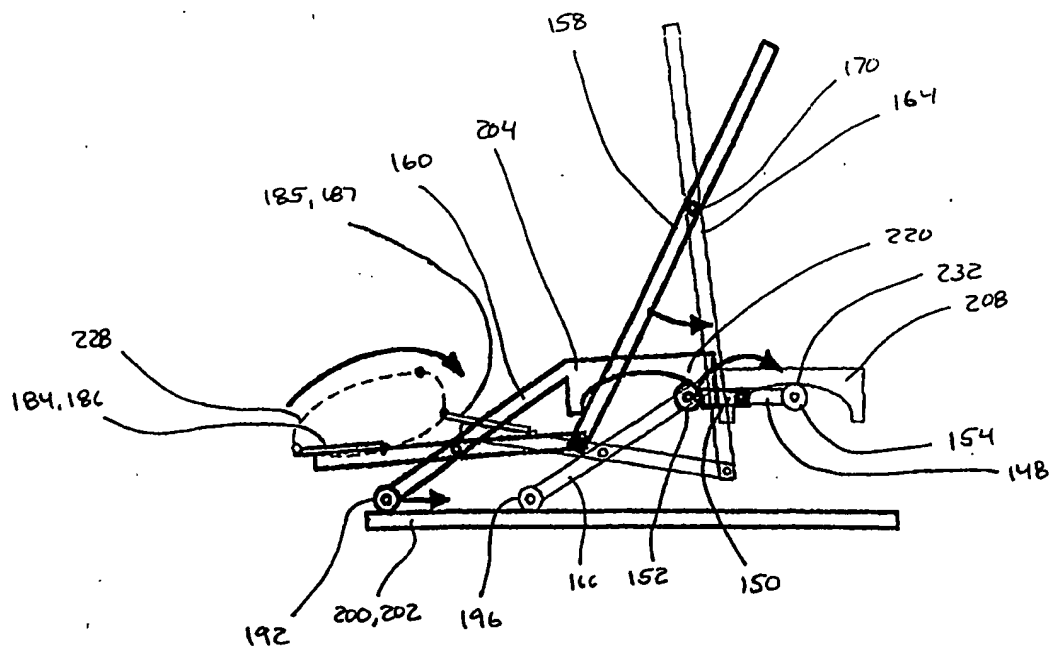


**Fig. 4C**

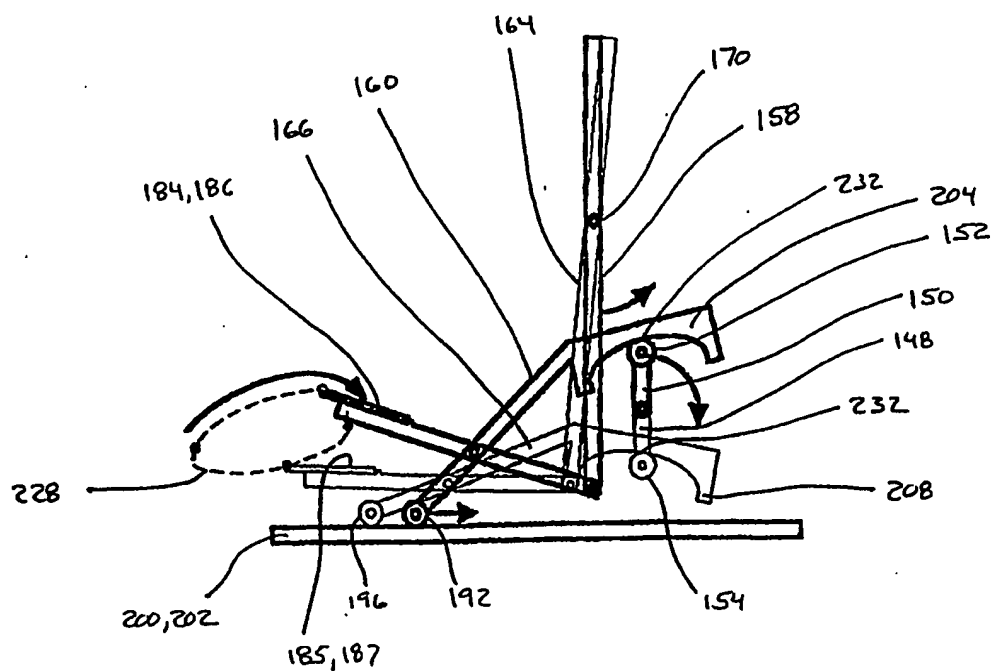


**Fig. 4D**

8/31

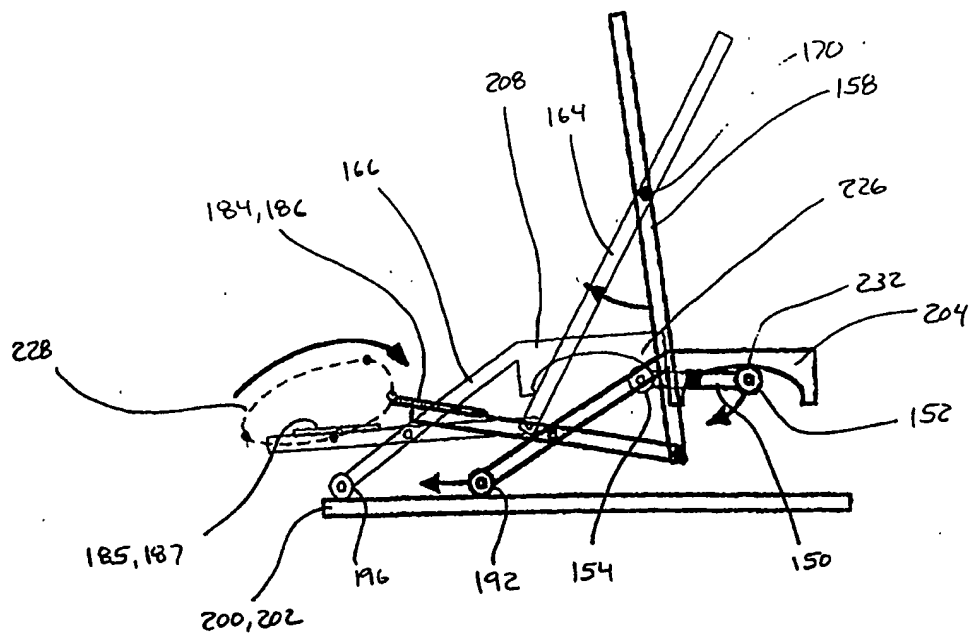


**Fig. 5A**

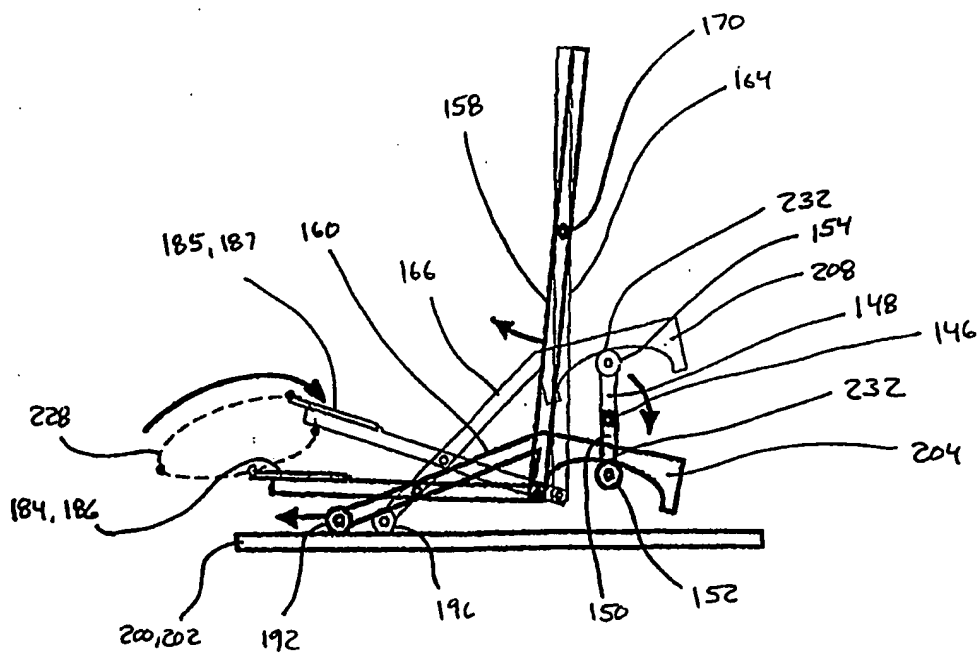


**Fig. 5B**

9/31

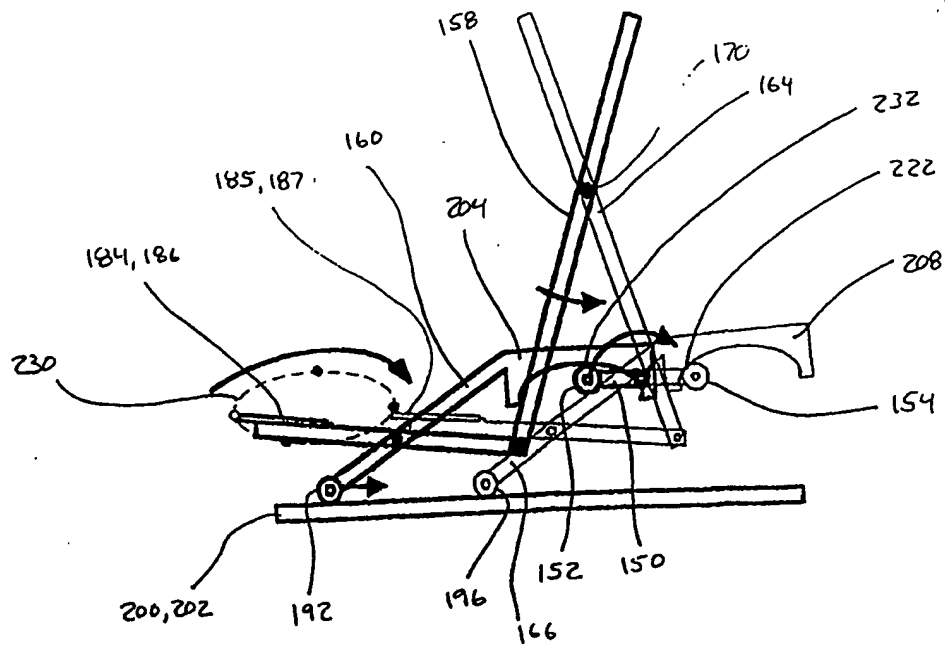


**Fig. 5C**

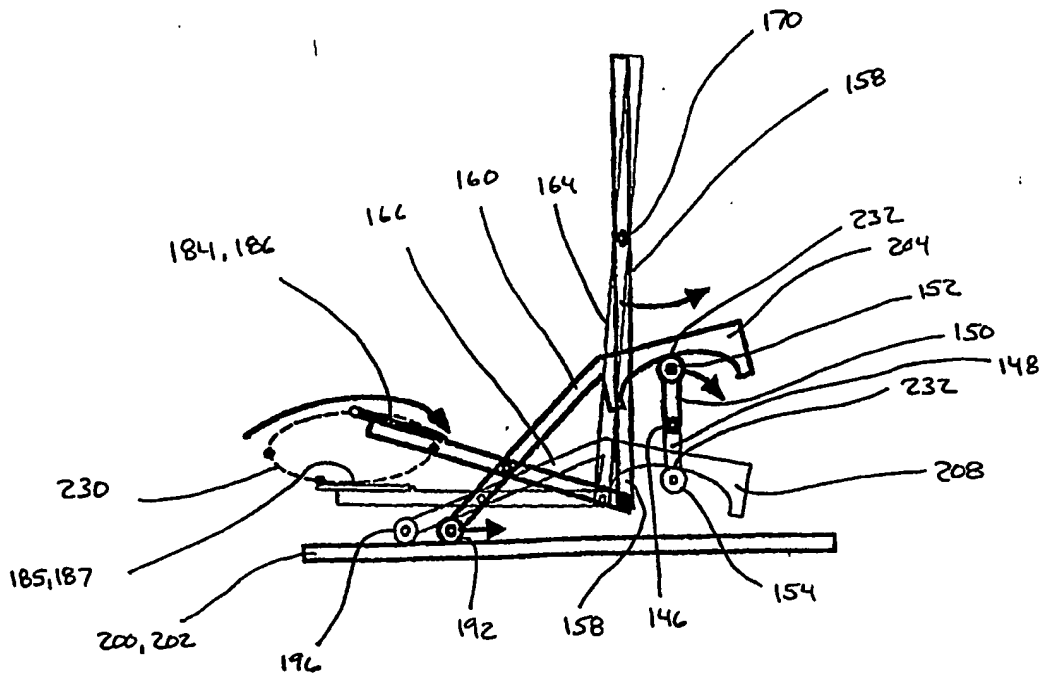


**Fig. 5D**

10/31

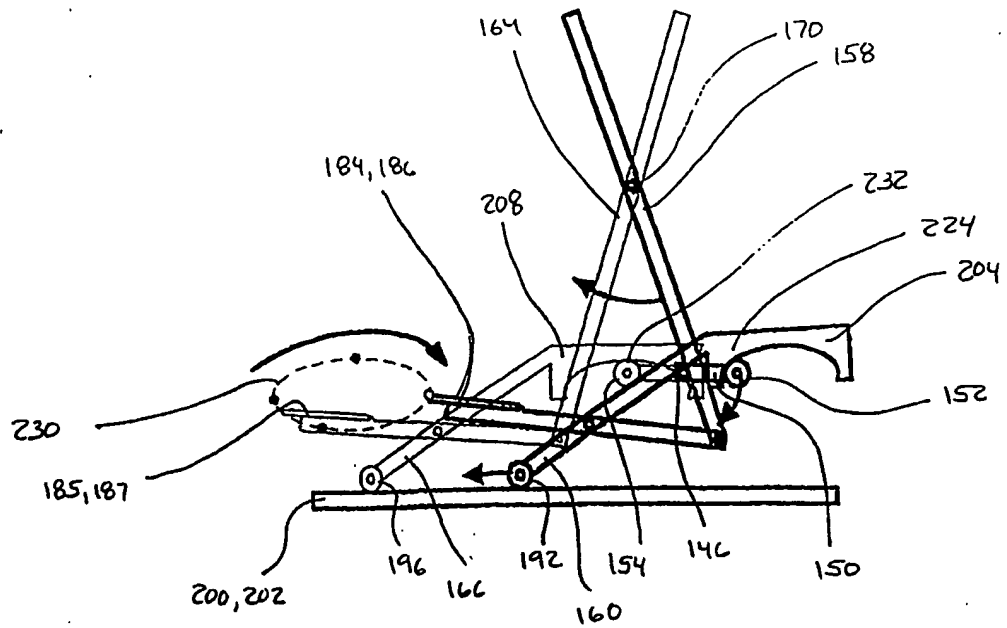


**Fig. 6A**

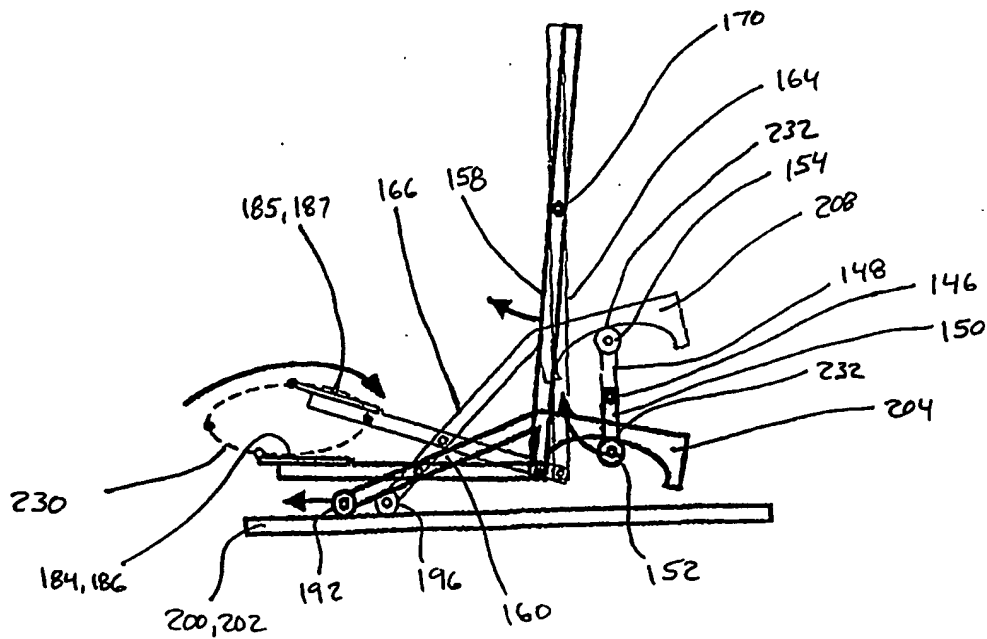


**Fig. 6B**

11/31

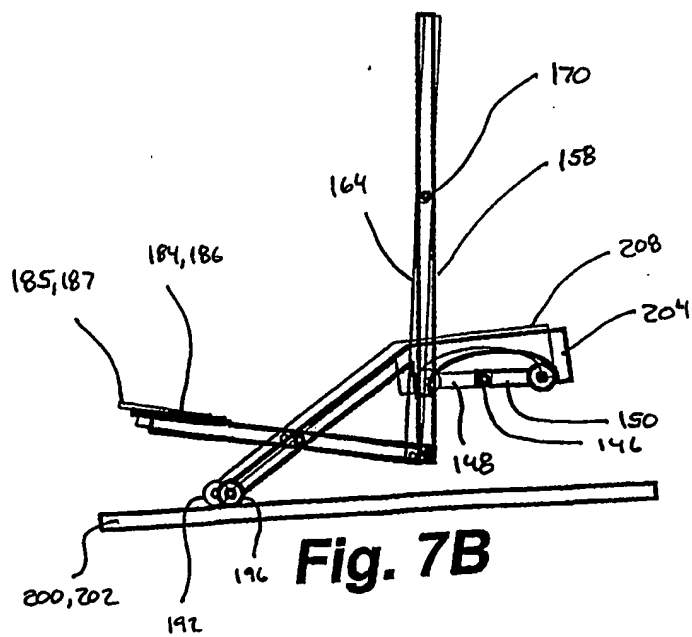
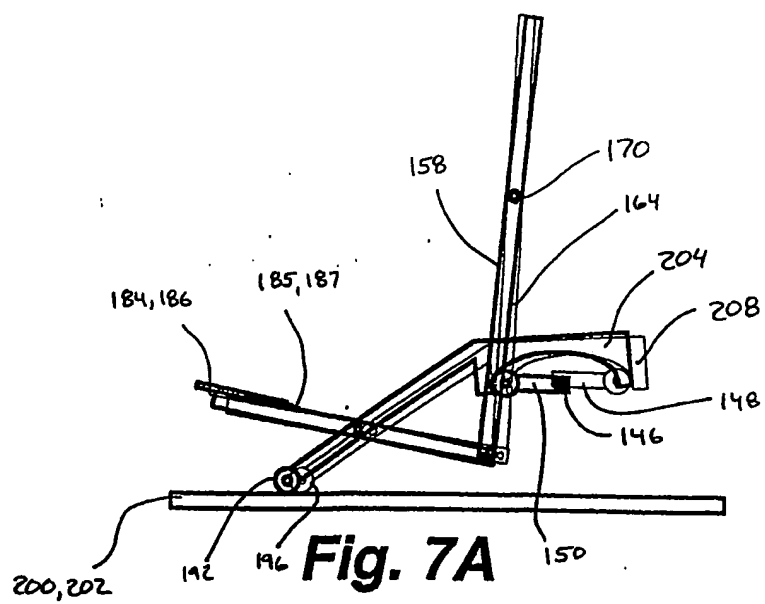


**Fig. 6C**



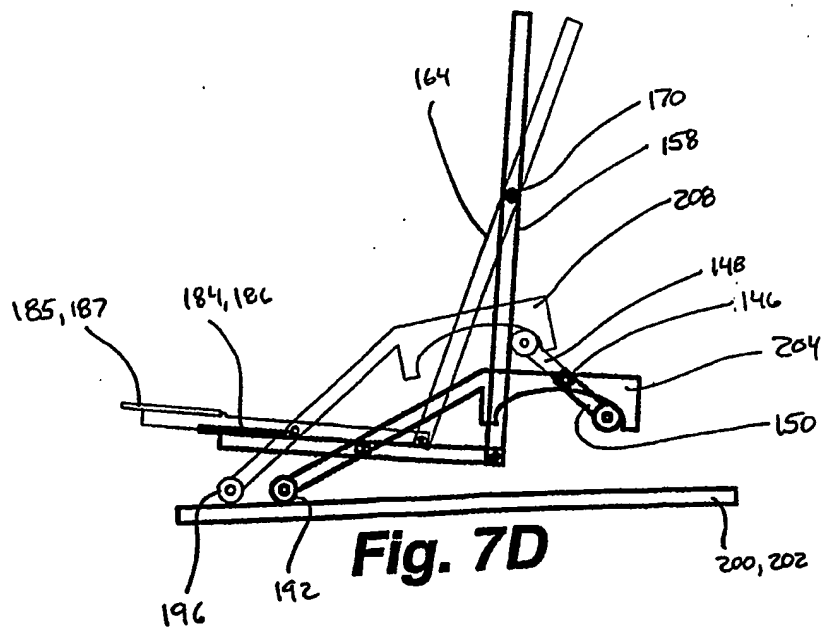
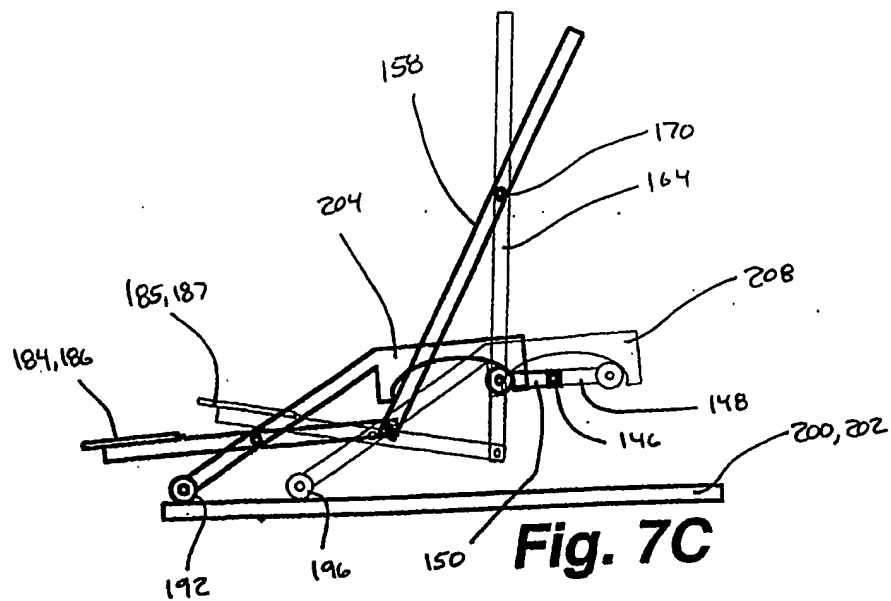
**Fig. 6D**

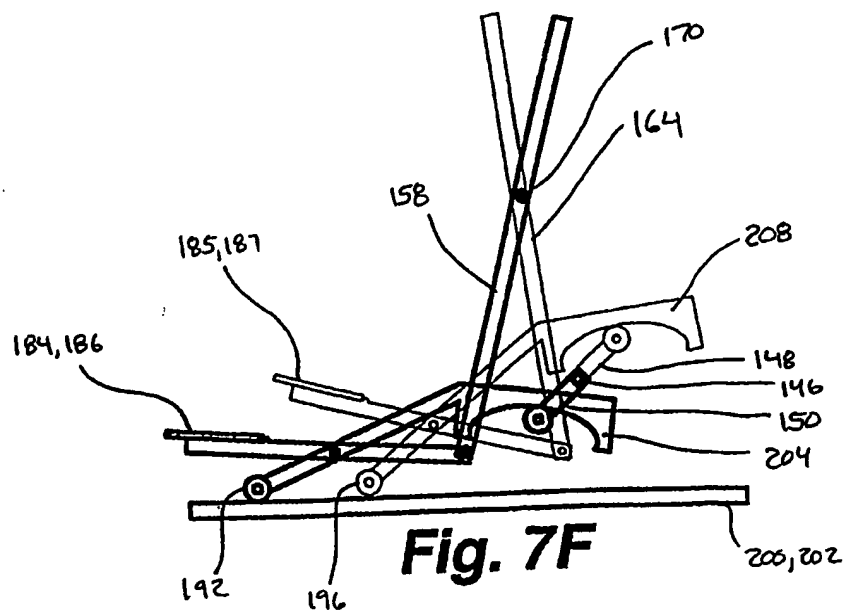
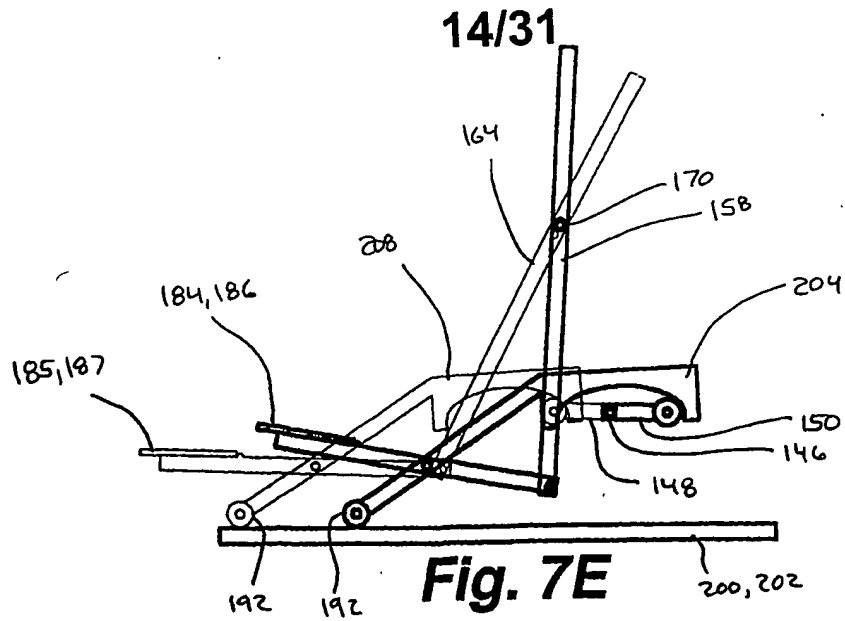
12/31



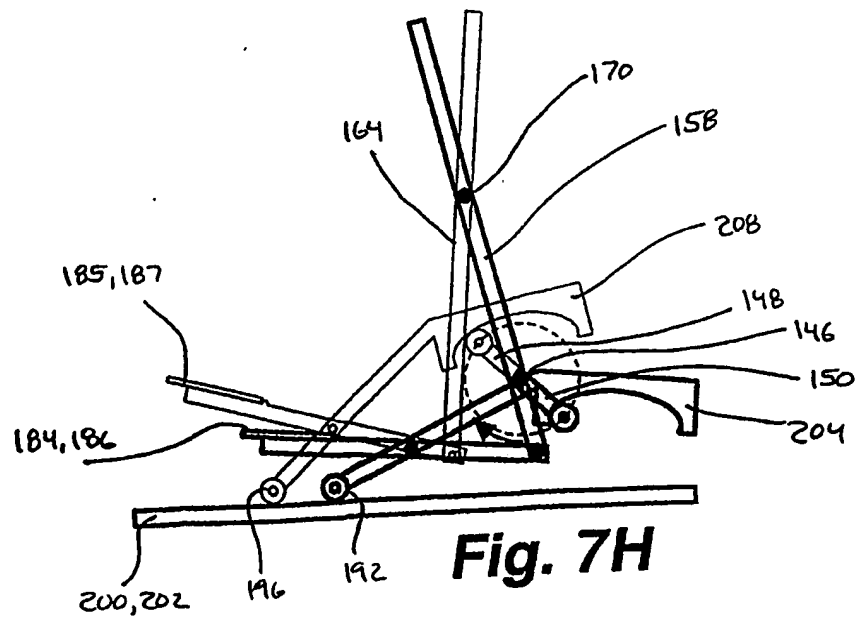
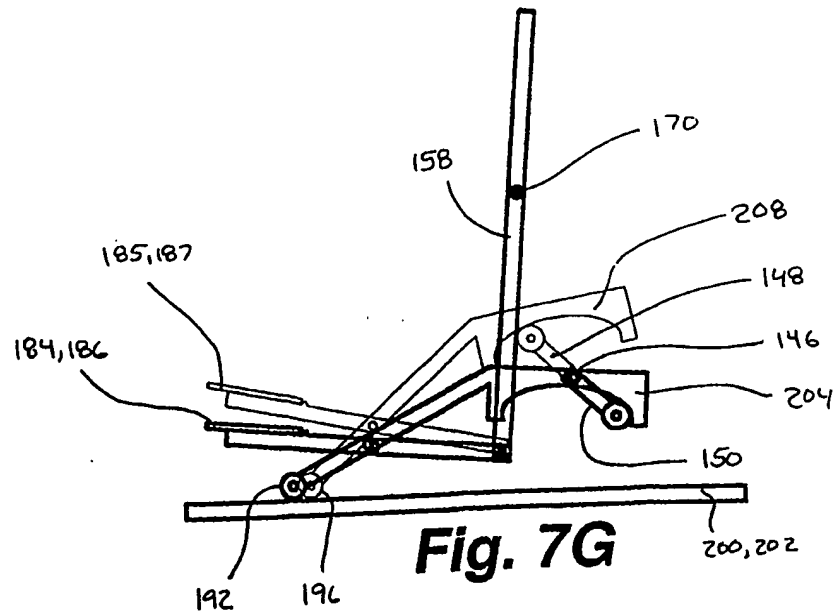


13/31

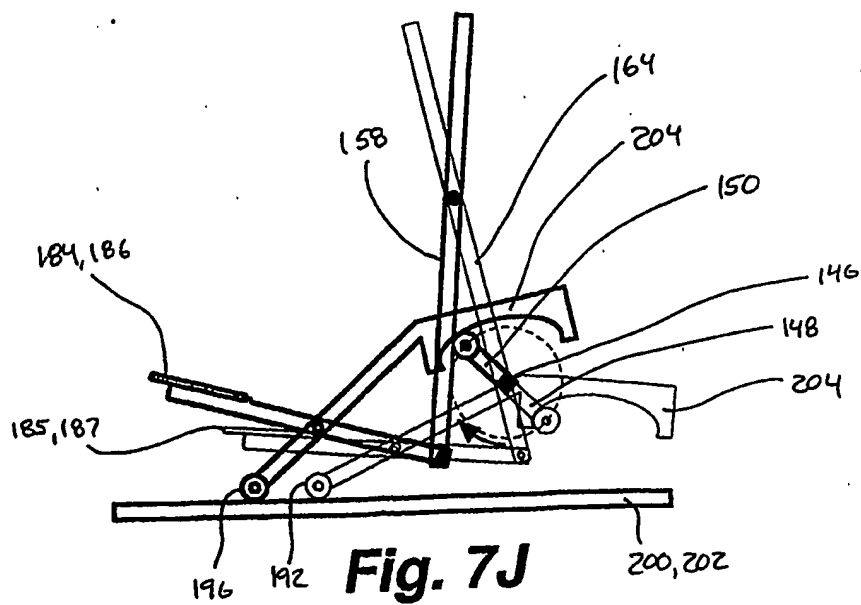
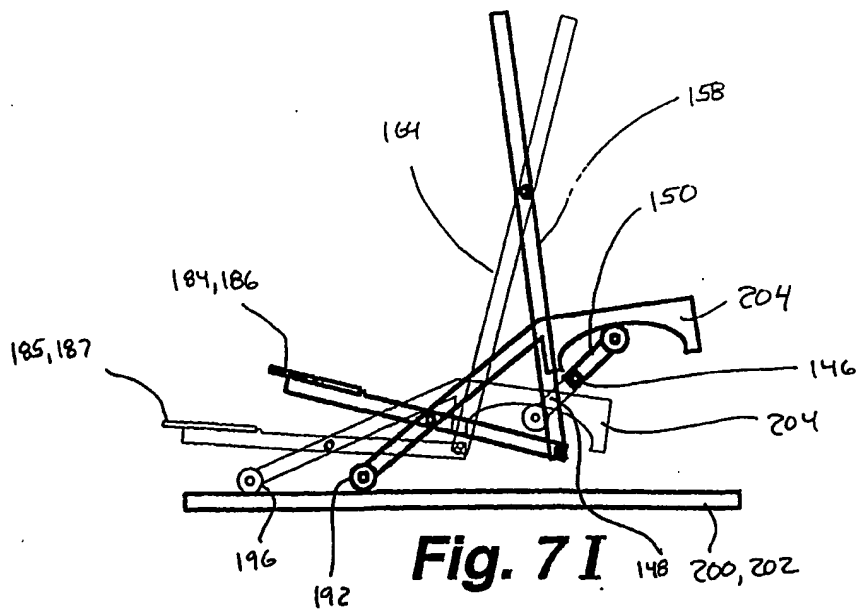




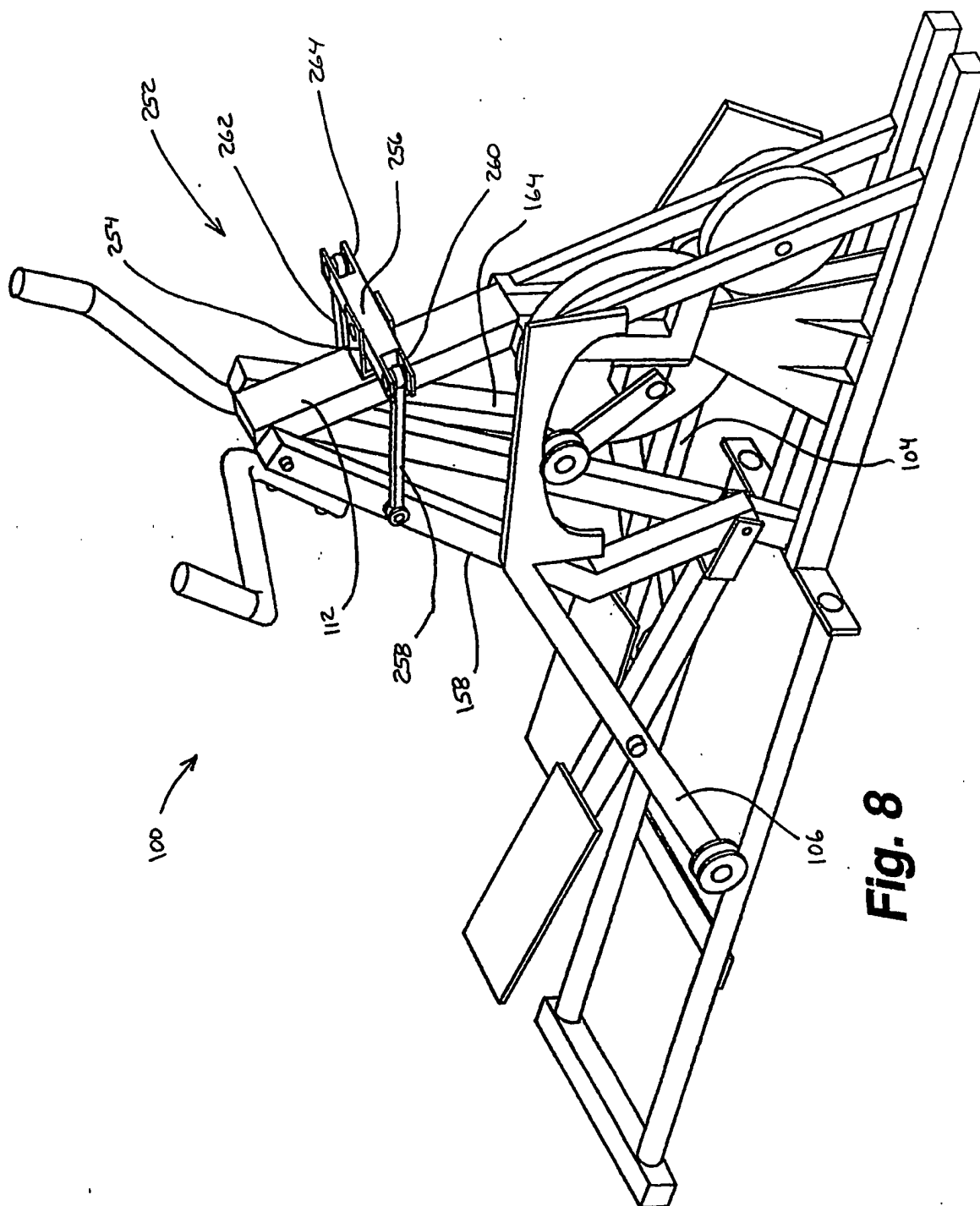
15/31



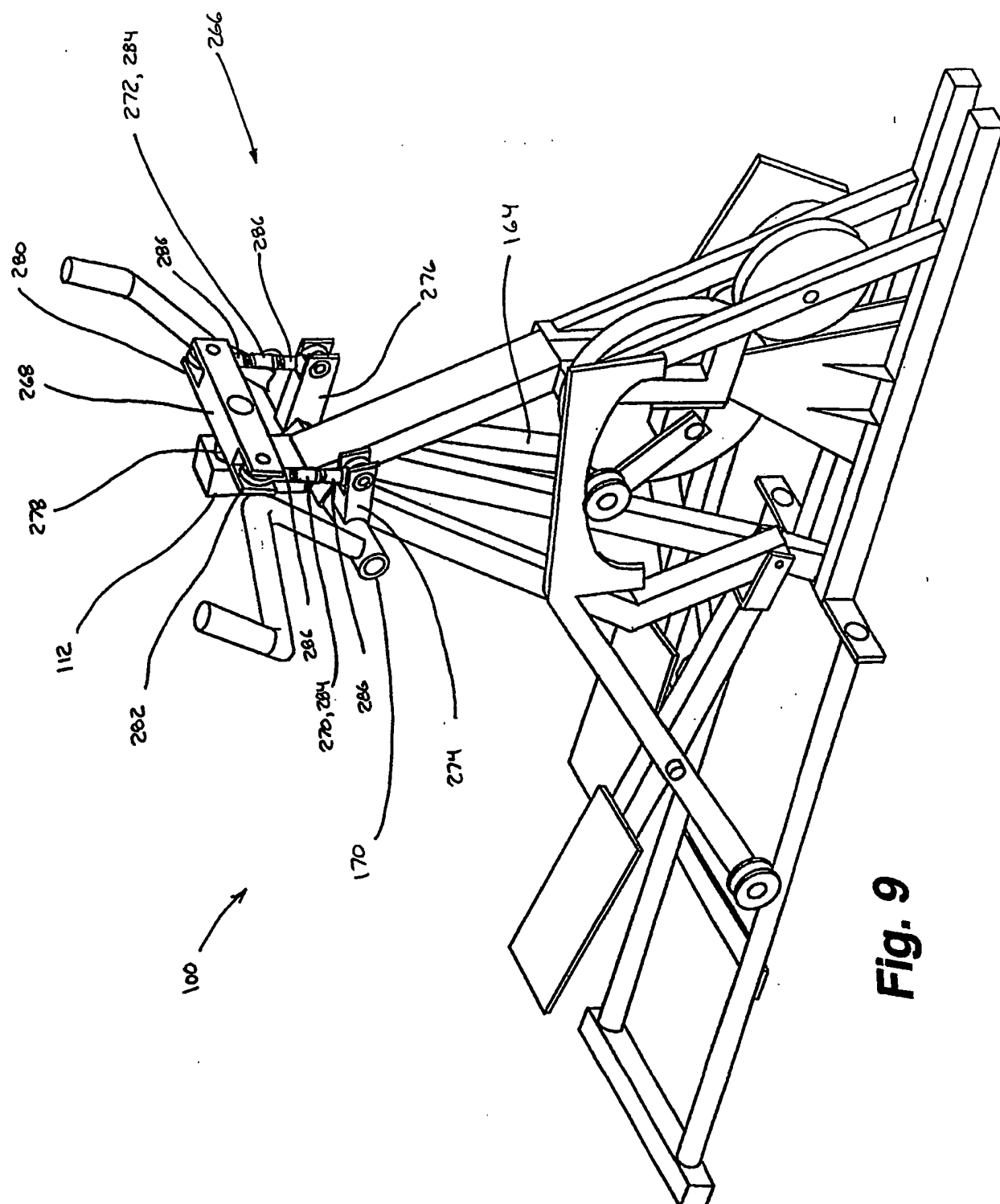
16/31



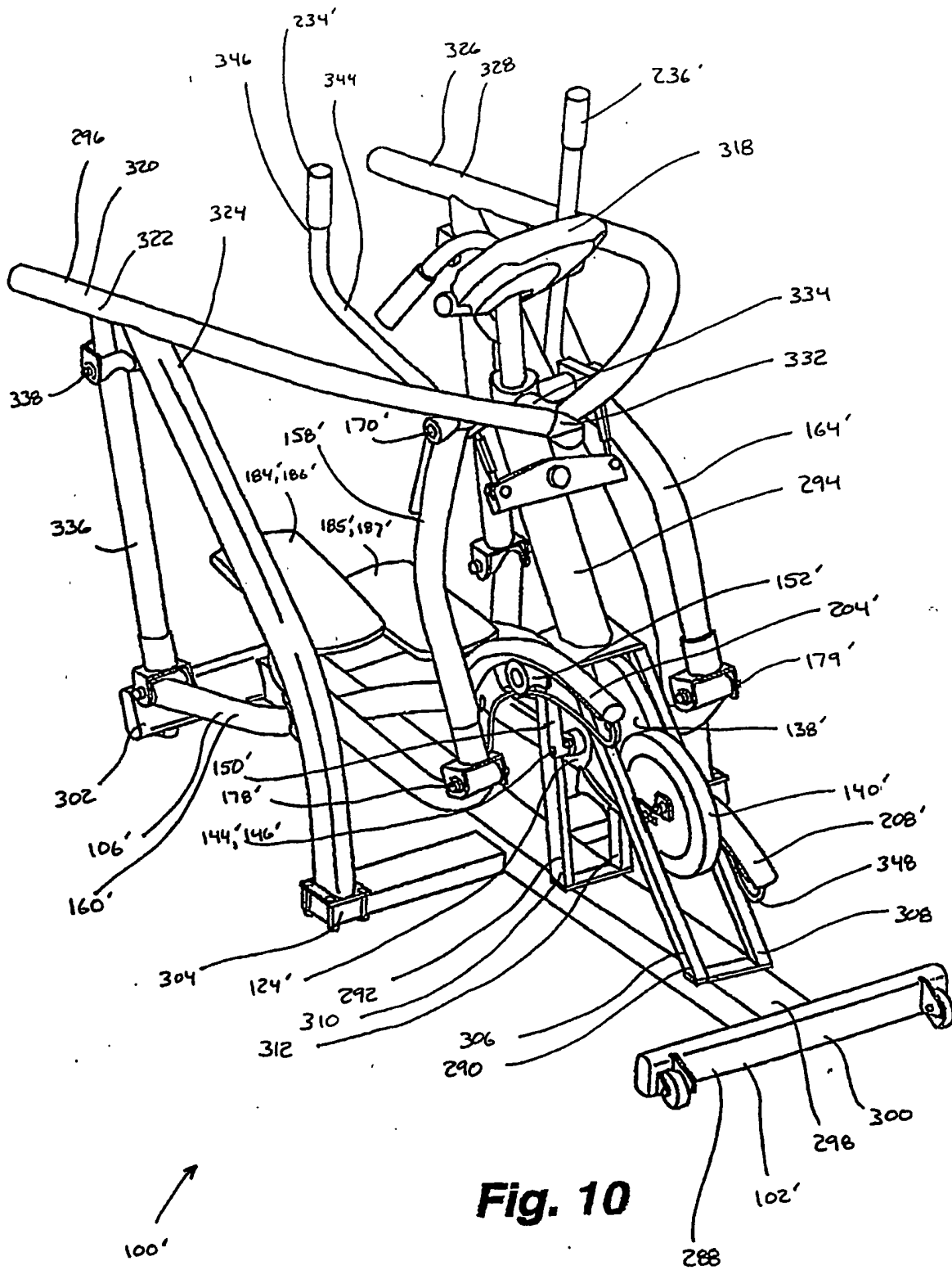
17/31



18/31

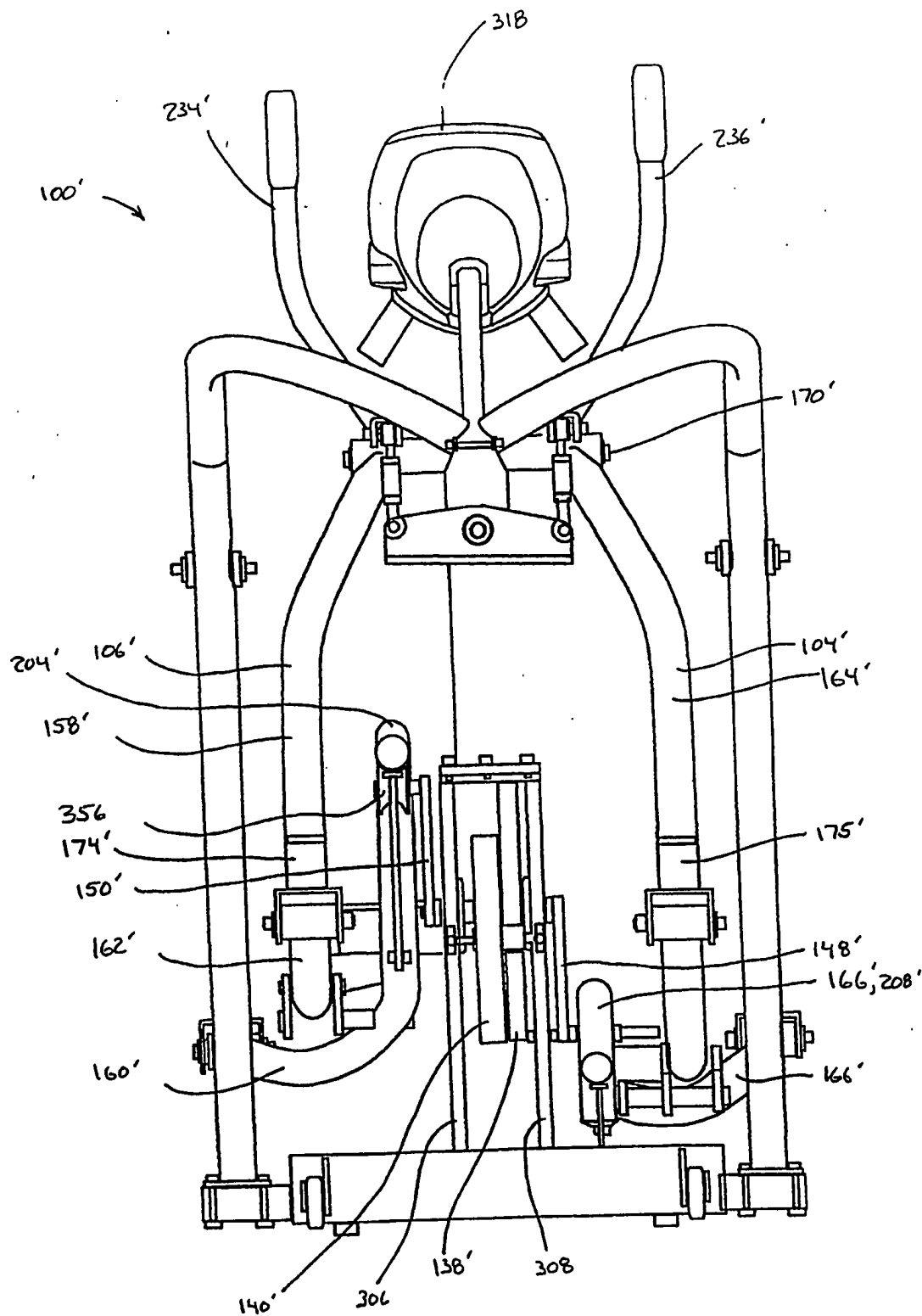


19/31



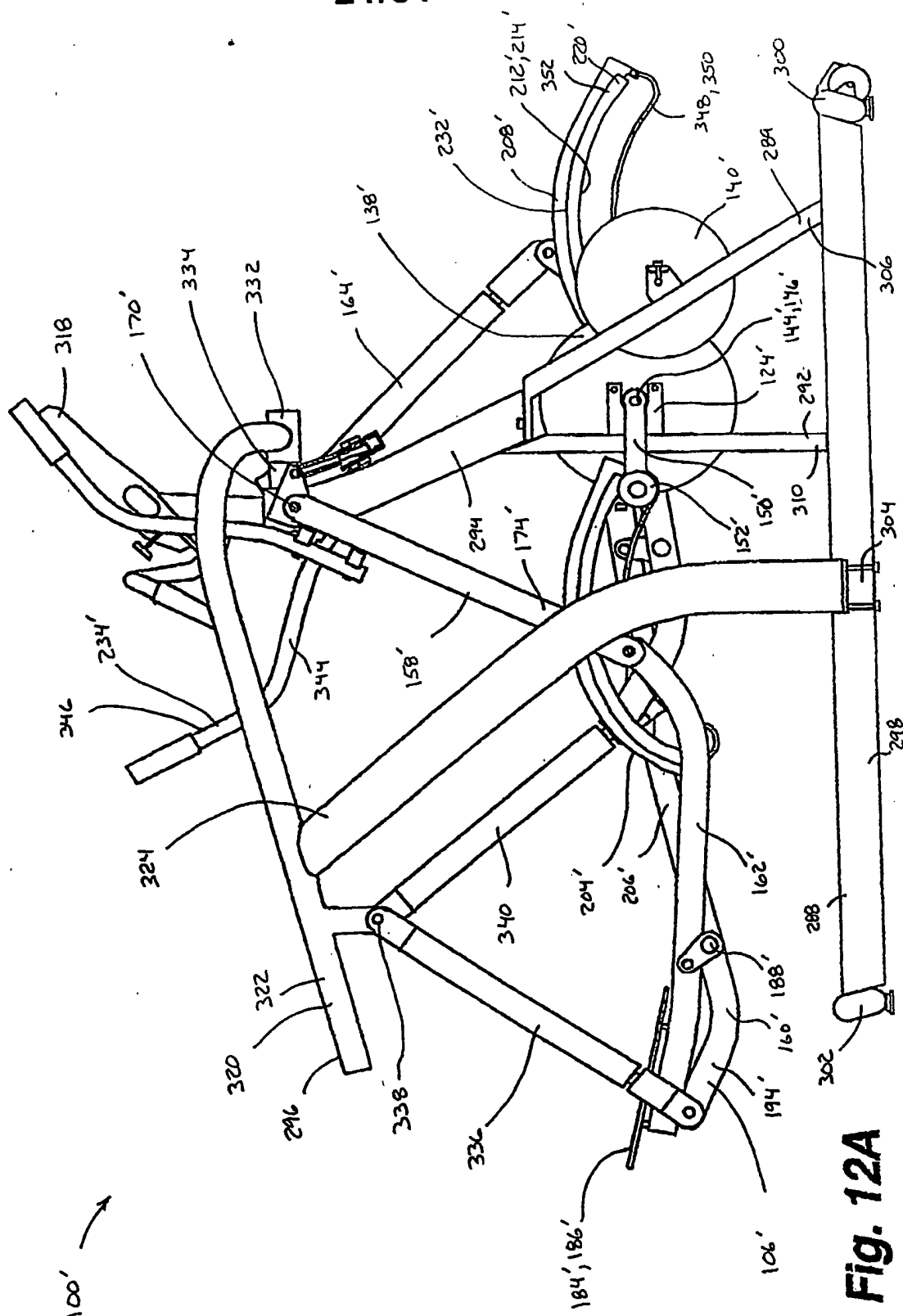
**Fig. 10**

20/31

**Fig. 11**



21/31



22/31

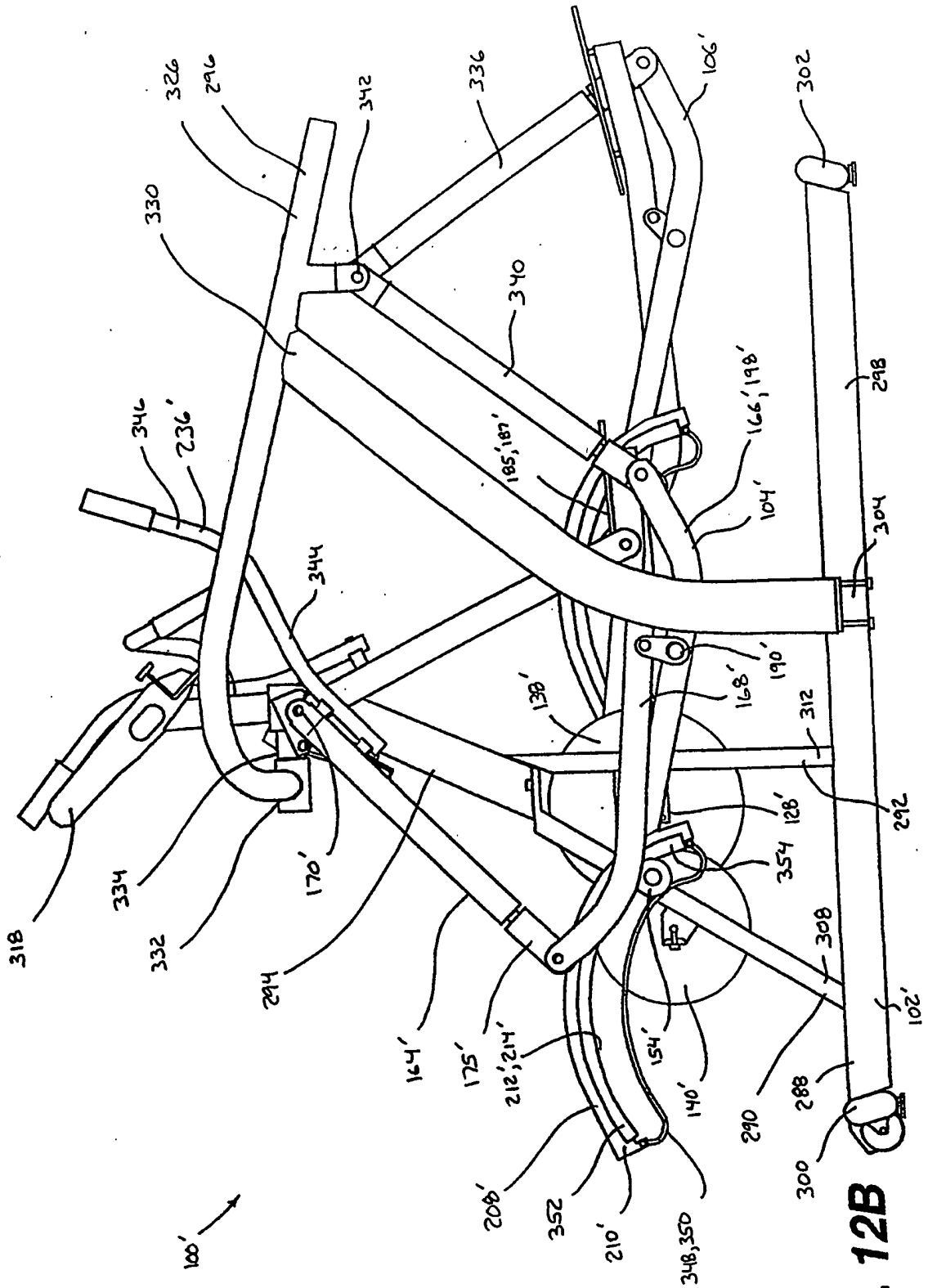


Fig. 12B

23/31

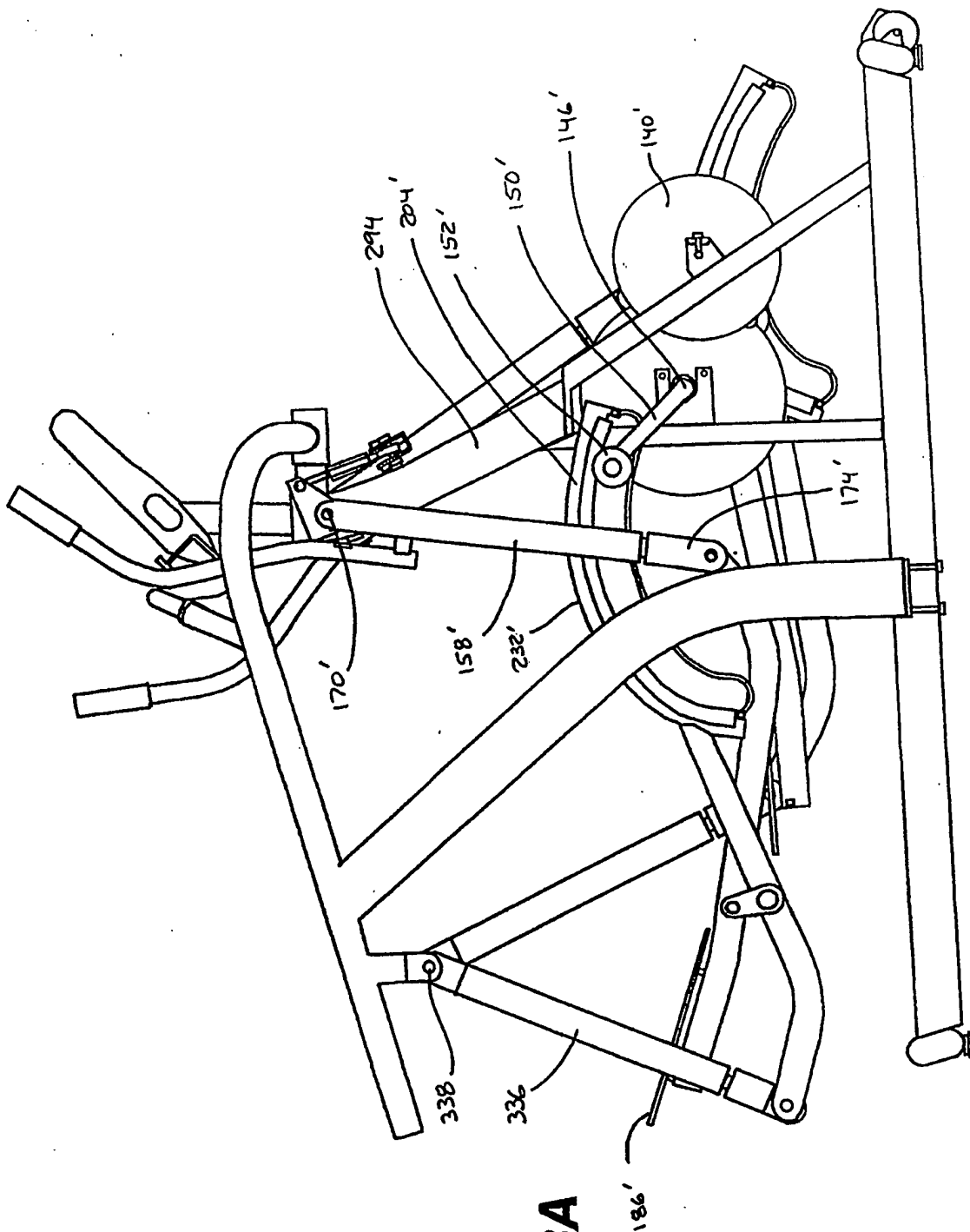
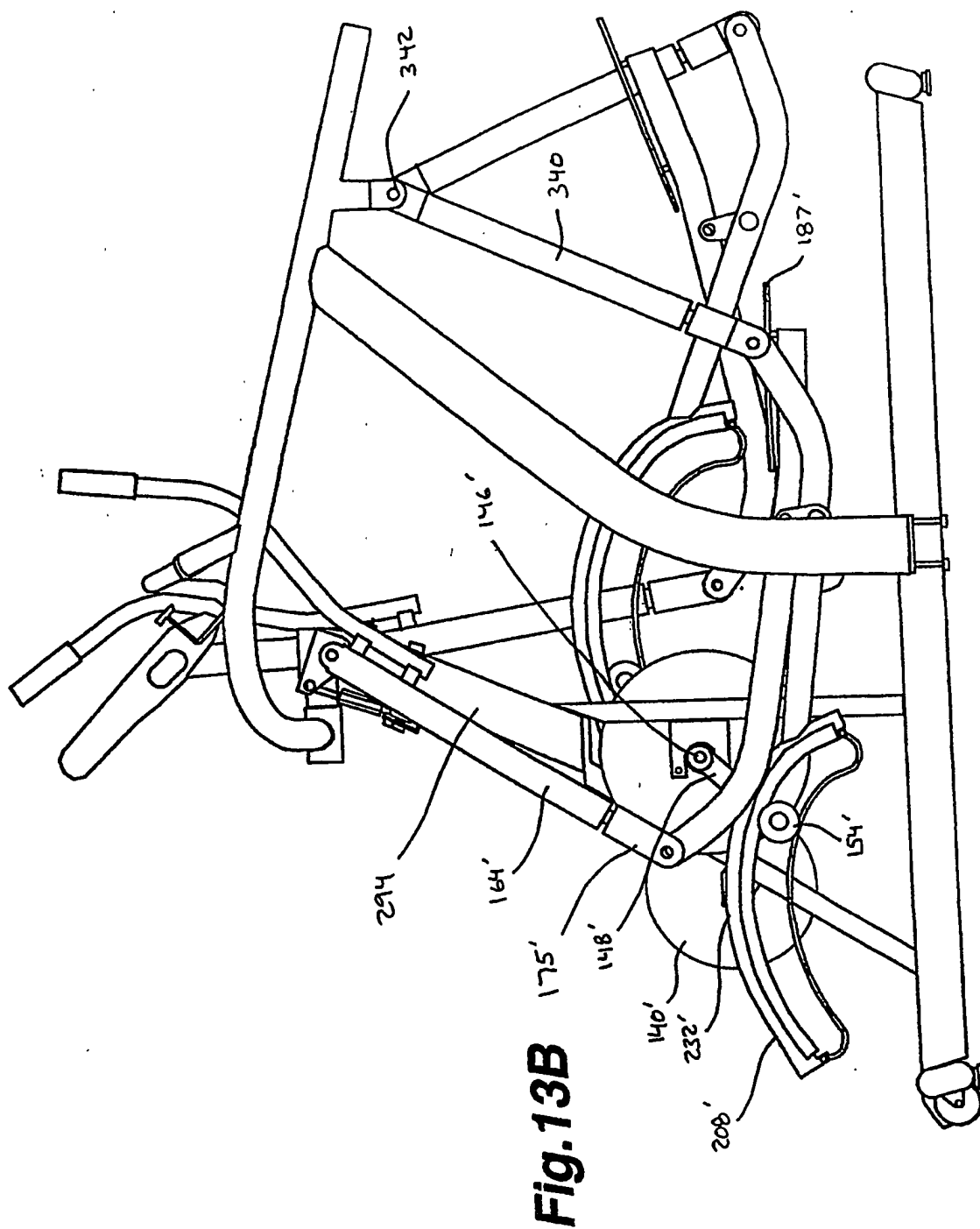


Fig. 13A

24/31



25/31

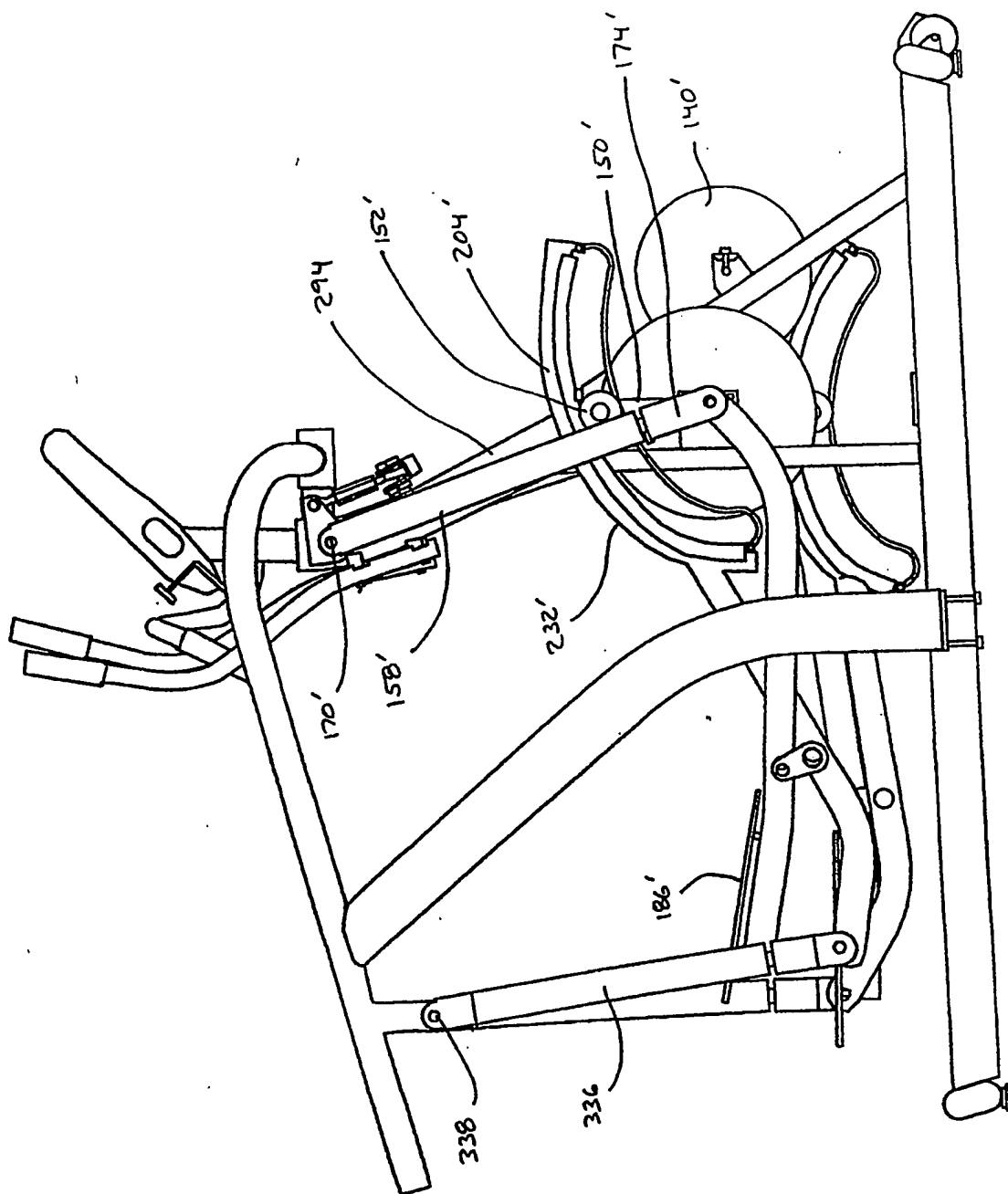


Fig. 14A

26/31

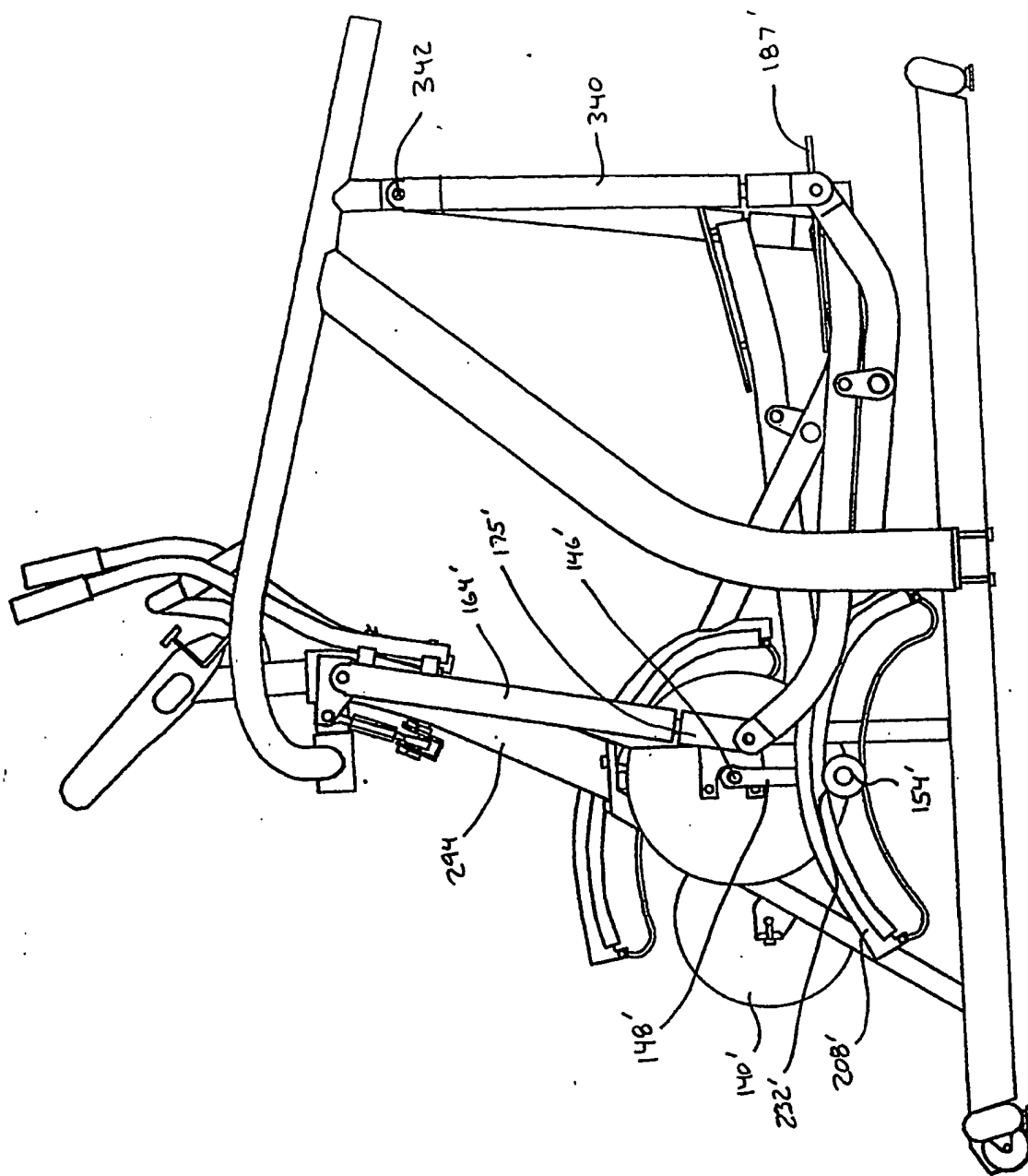
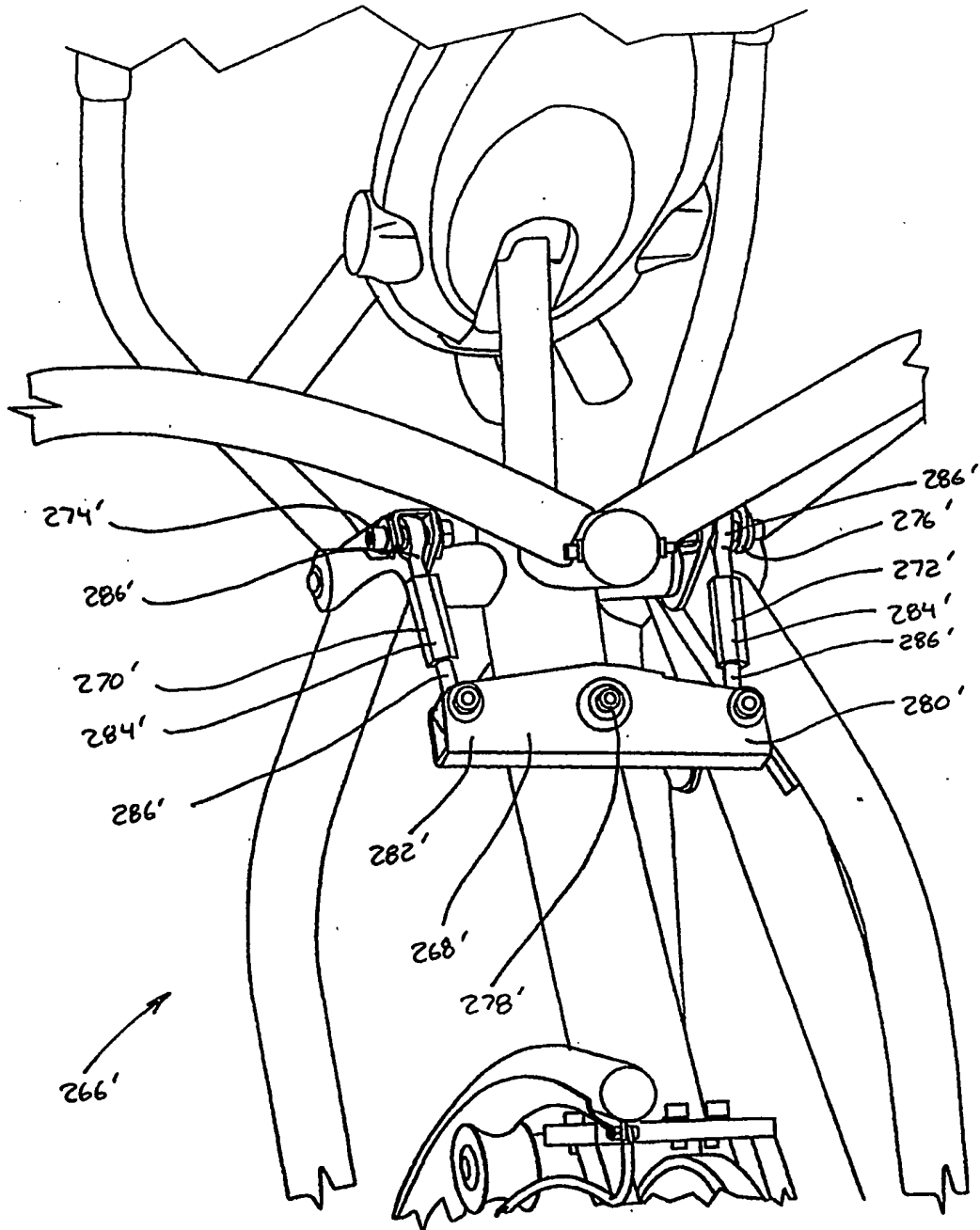


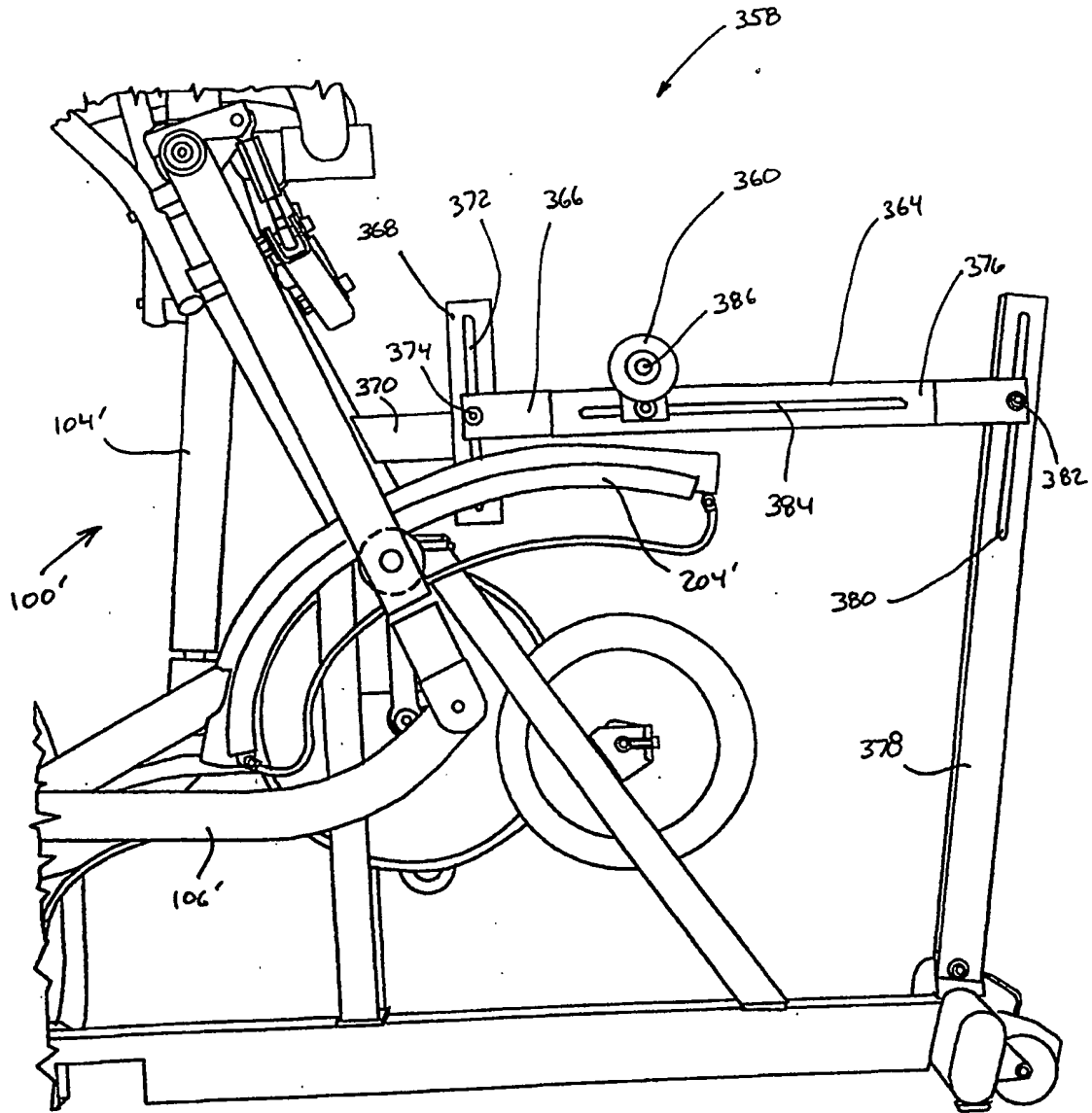
Fig. 14B

27/31



**Fig. 15**

28/31



**Fig. 16**



29/31

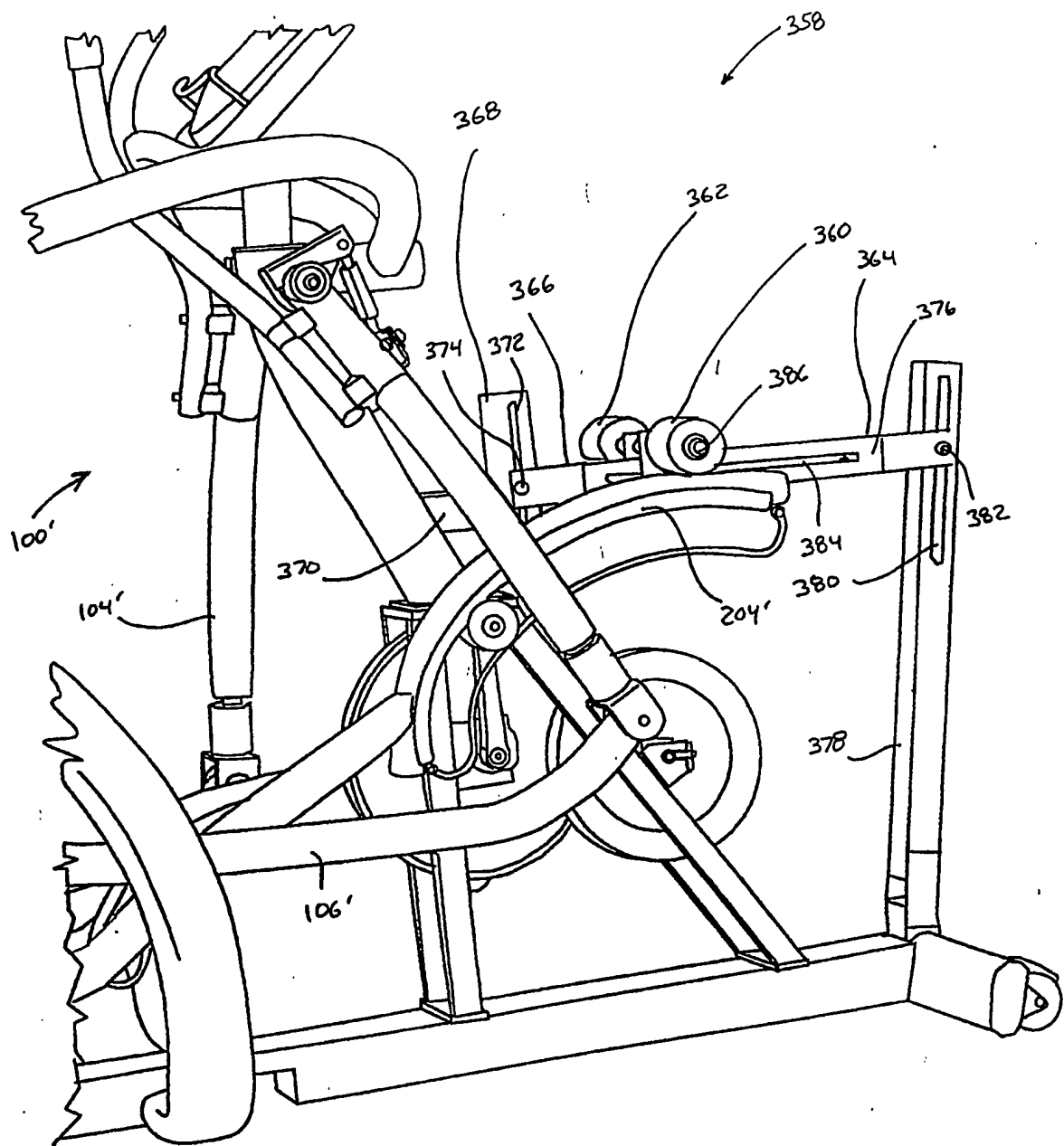
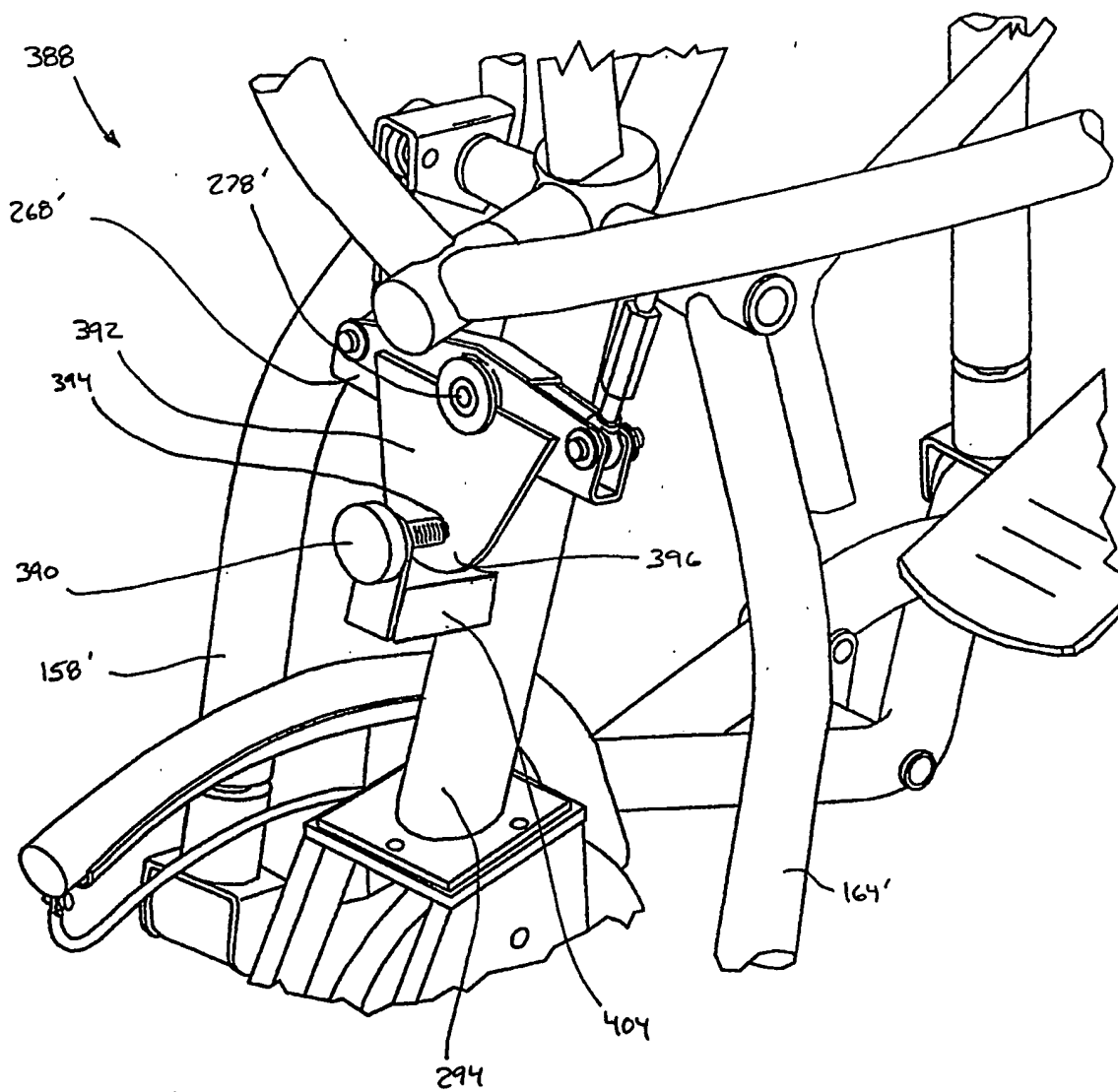
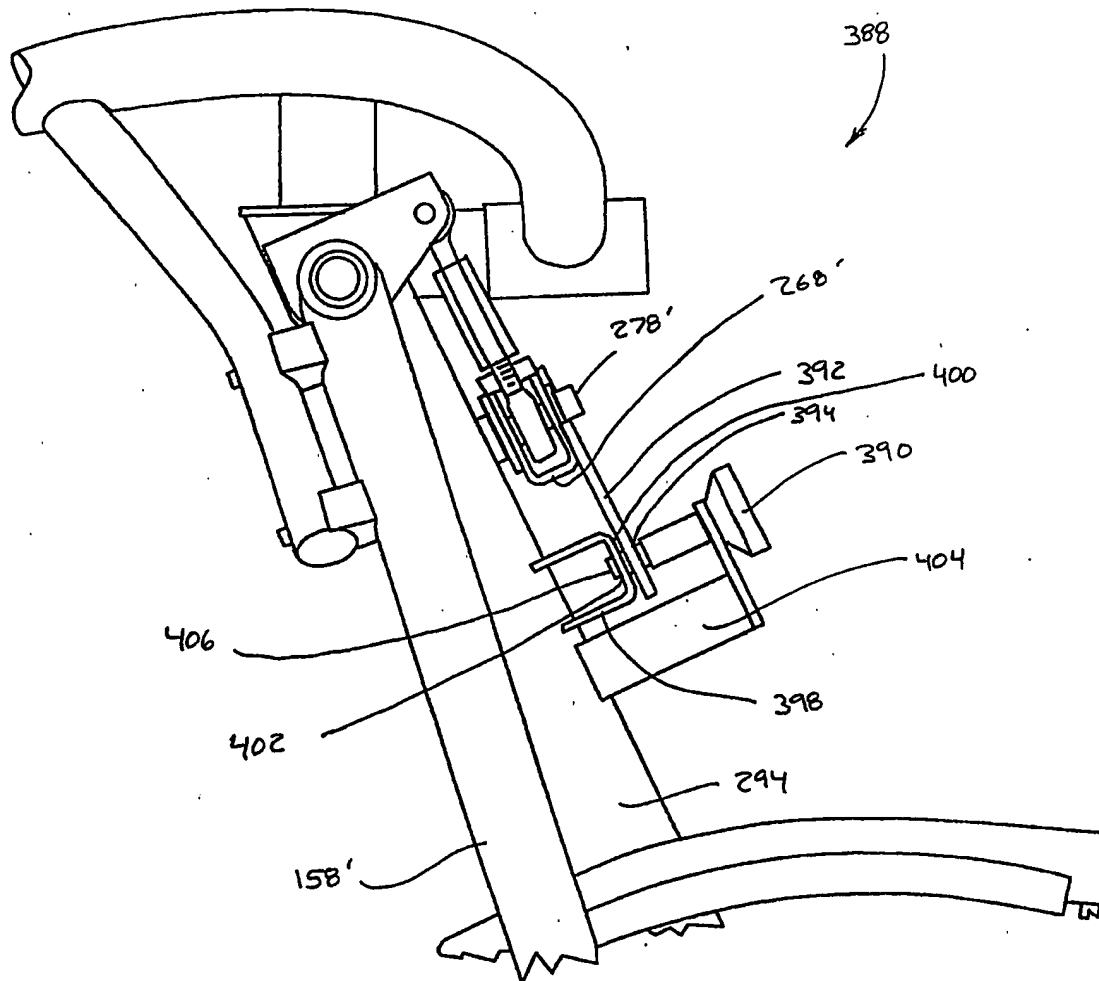


Fig. 17

30/31

**Fig. 18**

31/31



**Fig. 19**